DOCUMENT RESUME

ED 141 100 SE 022 575

TITLE The 4M coMpany: Make Mine Metric Monsters. Second Grade Teacher's Guide.
INSTITUTION Hawaii State Dept. of Education, Honolulu.; Hawaii Univ., Honolulu. Coll. of Education.
PUB DATE 76
NOTE 77p.; For related documents, see SE 022 570-583; Not available in hard copy due tc marginal legibility of original document
AVAILABLE FRCM Metric Project, University of Hawaii, 1776 University Ave., Honolulu, Hawaii 96822 ($3.00)

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS Elementary Education; *Elementary School Mathematics; *Instructional Materials; *Mathematics Education; *Measurement; *Metric System; *Teaching Guides

ABSTRACT

This is one of several teacher's guides for the 4M Company, a set of materials for teaching metric concepts and computation skills to elementary school students. Included in this guide are sections on needed materials, length (comparison, arbitrary units, meter, decimeter, centimeter, addition, subtraction), capacity (comparison, arbitrary units, liter, deciliter, addition, subtraction), mass (comparison, arbitrary units, gram, kilogram), temperature, and a minicourse on metrics. Answers to the activities in the related student activity manual are included. (RH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from cther sources. ERIC makes every effort *
* to cbtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the micrcfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible fcr the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

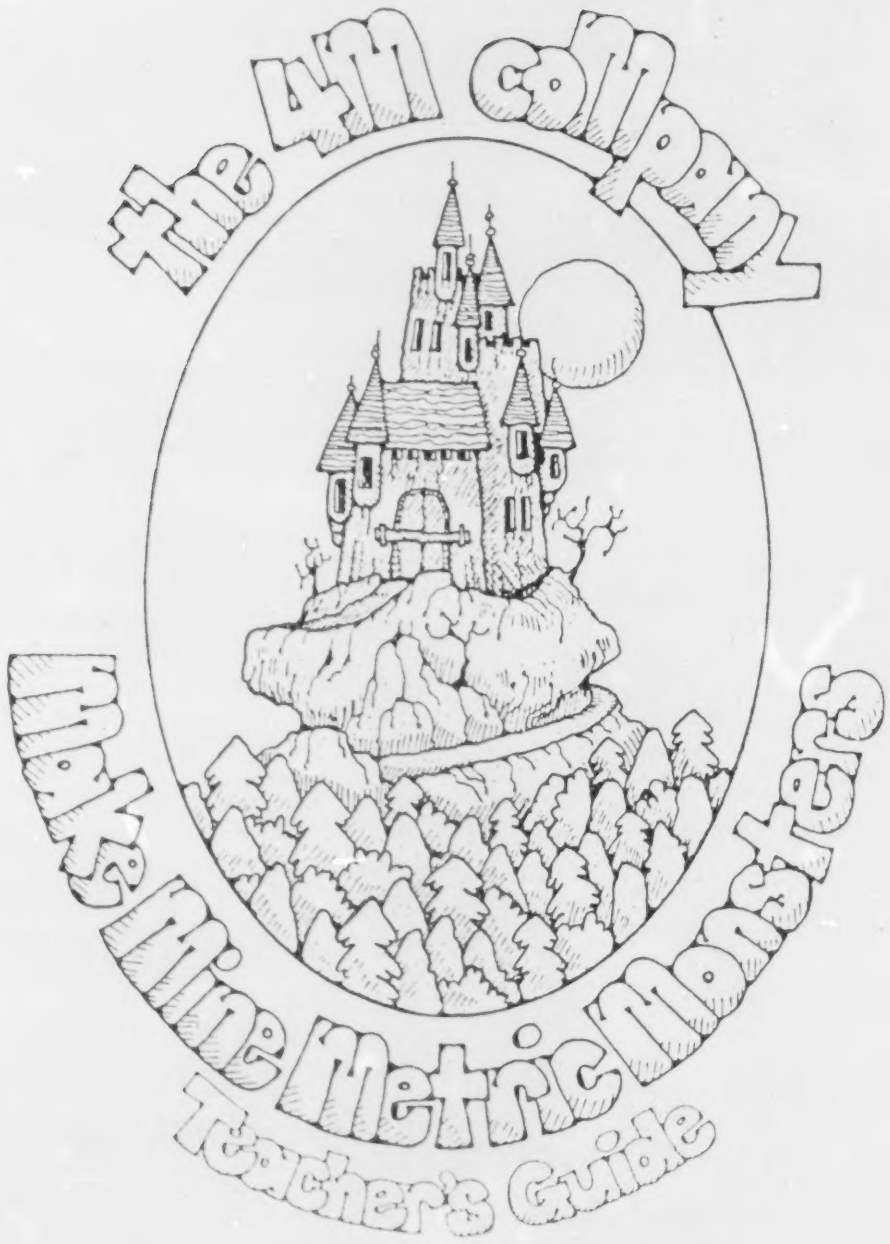
"PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY

Irvin L. King

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER"

ED141100

SE 022 575



presents

the metric system

starring the

MAKE MINE METRIC MONSTERS

project staff:

Irv King, Director

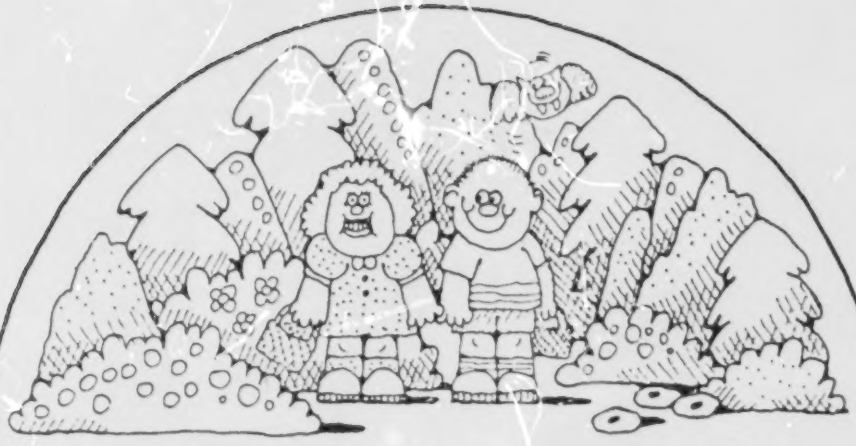
Kathleen Berg, Curriculum Planner

Kini Haines, Artist

a cooperative effort of
the University of Hawaii
and the Department
of Education

© 1976 University of Hawaii
College of Education
Curriculum Research and Development Group

Make Mine Metric Monsters
DRACULITER
KILLER GRAM
SEEMORE CELSIUS
DR. FRANKEN
METER MUMMY
JANE AND JIM
IGOR
DR. FRANKEN'S STEIN



Jim and Jane went for a walk in the forest to pick blueberries. They soon became lost and wandered deeper and deeper into the forest. As it was getting dark, they saw a light. It was a huge, spooky castle. Jim knocked on the door, and a tall man in a white coat opened the door.

"Velcome, I am Dr. Franken, the mad scientist. Who are you?", he said.

Jim and Jane explained their plight. Dr. Franken invited them into his castle.

"You are velcome to stay in the castle tonight. But, whatever you do, don't go into the Meter Room, the Liter Room, the Gram Room, or the Celsius Room. The secrets of the metric system are in these rooms, but there are also terrible monsters lurking there," he warned them.

Dr. Franken and his assistant, Igor, then fed them supper and showed them to their rooms. To find out what happened next, read on...

the 4th company

the 4m company

table of contents.

TO THE TEACHER 1

MATERIALS 4

SECTION 1 6
LENGTH - COMPARISON

SECTION 2 9
LENGTH - ARBITRARY UNITS

SECTION 3 11
LENGTH - METER

SECTION 4 14
LENGTH - DECIMETER

SECTION 5 17
LENGTH - CENTIMETER

SECTION 6 20
ADD UNITS OF LENGTH

SECTION 7 22
SUBTRACT UNITS OF LENGTH

SECTION 8 24
CAPACITY - COMPARISON

SECTION 9 26
CAPACITY - ARBITRARY UNITS

SECTION 10 27
CAPACITY - LITER

SECTION 11 30
CAPACITY - DECILITER

SECTION 12 33
ADD UNITS OF CAPACITY

SECTION 13 35
SUBTRACT UNITS OF CAPACITY

SECTION 14 37
MASS (WEIGHT) - COMPARISON

SECTION 15 39
MASS (WEIGHT) - ARBITRARY UNITS

SECTION 16 40
(MASS (WEIGHT) - GRAM

SECTION 17 43
MASS (WEIGHT) - KILOGRAM

SECTION 18 46
TEMPERATURE

SECTION 19 49
"I MEASURE ME"

APPENDIX
MAKE MINE METRIC MINI-COURSE

the 4M company

to the teacher ooo
read carefully before
you begin teaching

Curriculum materials are only one of the factors involved in the learning process. No program can anticipate the other factors - your unique characteristics as a teacher, the characteristics of your students, and your classroom situation. Yet these factors must all be considered for a successful learning experience. It is you, the teacher, who must analyze these factors to make decisions and adjustments in the learning activities as described in this Teacher's Guide.

The 4M COMPANY provides a variety of classroom organizations: at times students will work as an entire class, at times they will work in small groups, and at times they will work alone. Depending on the unique combination of factors which make up your classroom, the procedures recommended in this Teacher's Guide may or may not work in your particular classroom. Feel free to adapt the program to meet your particular needs. Following the Teacher's Guide word-for-word is not important; learning the objectives of the program is!

You are a unique person, and no one will teach The 4M COMPANY exactly as you do. Your strengths, your weaknesses, your abilities, and your overall philosophy will influence your teaching. Keep in mind, however, the following roles which you must play as a teacher.

The role of a planner. The 4M COMPANY is an activity program, and you will be required to prepare materials for most lessons. Things will not always work out as you had planned, so be prepared to alter your plans if the need arises.

The role of a demonstrator. Although this Teacher's Guide outlines one approach to teaching the objectives of a lesson, you must decide if a given demonstration is working with your students. They are unique, and you may have to alter the demonstrations to meet their level of understanding.

The role of a questioner. Instead of always giving answers, ask the children remedial questions that will clarify their thinking. Ask more difficult questions of children who need more challenge.

The role of a motivator. No student can be made to learn if he doesn't want to. The 4M COMPANY has tried to motivate children in several ways - the cartoon format of the booklets, the use of a story line for each grade level, and the use of games and activities. But in addition to our efforts, you will still need to motivate and encourage children to learn.

The role of a summarizer. At the conclusion of an activity, you encourage students to share their findings. It is important to summarize the results of each activity.

We have tried to make The 4M COMPANY an enjoyable and effective metric program. To a large extent your attitude will determine the success of the

program. If you are unfamiliar with parts of the metric system, admit this to yourself and to your students. If you adopt a positive attitude of learning with your students, this will do much to create a good classroom environment. For ready reference, the Appendix to this Teacher's Guide contains a brief review of the metric system.

The following paragraphs deal specifically with this level of THE 4M COMPANY.

content

At this level students proceed systematically through a carefully sequenced series of activities, including direct and indirect comparison of physical properties, measuring with arbitrary units, and measuring with standardized metric units. Measurement activities involve meters, decimeters, centimeters, liters, deciliters, grams, kilograms, and degrees Celsius. Special attention is given to measurement technique, i.e., how to measure. Students are encouraged to estimate before measuring in order to help them "think metric". Computation with expressions involving metric units provide a direct application of the metric system to the real world. Verbal problems play an important role in the student's growing awareness of the usefulness of measurement.

management

Management will be a key factor in the success of The 4M coMpany. Seatwork that reinforces metric concepts or vocabulary has been included in key places in the program to help alleviate the classroom management problems that accompany accivities. Many students enjoy coloring the pictures in their metric booklets. This can serve as an aid in classroom management. While you work with a small group, others can color in their books. However, no child should be forced to color, and care should be taken not to compare or judge the quality of the coloring.

estimating

Throughout the program children should be encouraged to estimate before measuring. Encourage careful measuring, but explain that no measure is exact. Use the words "about" or "almost" to describe inexact measurements.

reinforcement

Experience has shown that retention of metric concepts and vocabulary will occur only if they are reinforced throughout the school year. Make a flashcard for each metric unit and another for its symbol. Use these frequently to reinforce metric vocabulary. It is also a good idea to set metric units in front of the class and have them identify the various units by name. Familiarity with the units is a major goal of the program, and this can be achieved by frequent drill and review.

rounding off

Measurement provides an easy, visual model for teaching students how to round off: the measurement is rounded off to the nearest unit by merely looking at the measuring instrument. It is not until later that students will be taught how to round off written expressions. At this time rounding should be kept at an informal, concrete level.

metric chart

It is recommended that each classroom have a chart of the metric system. Put one up early in the year and as each metric unit is introduced, point it out on the chart. The last page in this Teacher's Guide may be used to make a colorful poster where each unit can be highlighted with color when it is introduced. The page may be removed, used to make on overhead transparency,

and the overhead projector used to enlarge the chart onto a piece of poster board where it can be traced and colored. An opaque projector may be used to accomplish the same thing using the page directly.

spelling

At the time of printing there was no national policy on the spelling of the words "meter" and "liter". Some groups are advocating "metre" and "litre". We have gone with the "er" spellings. However, since students will probably see both spellings, it is a good idea to expose them to both. Both spellings are correct.

the 4th company

Materials

section number	materials description
1	pencils (3 the same length, others different lengths), masking tape, string, strips of paper (activities 6 and 7)
2	a long and a short pencil, children's crayons, 7-8 paper clips per student
3	meter sticks with masking tape covering all printing and subdivisions, masking tape, adding machine tape
4	meter stick with masking tape covering all marks, 10 decimeter strips (cut from back of Teacher's Guide), meter stick marked in decimeters, one meter long strip of adding machine tape, glue or tape
5	plain meter stick; decimeter ruler; centimeter unit (cm cube or unit cut from back of Teacher's Guide); cm ruler (cut from back of Teacher's Guide); 6 cards and a marker to make flashcards (activity 8); dm strip (cut from back of Teacher's Guide)
6	meter stick, dm ruler, cm ruler, adding machine tape
7	adding machine tape, dm ruler
8	two identical transparent containers (baby food jars are good), 1 tall thin container (stuffed olive jar is good), 1 short wide container, water (colored water works well), large jar or pitcher to use as a reference container, magic mending tape, 3-4 sets of 3 containers of different shapes but nearly the same size (label one set 1, 2, 3; one set A, B, C; one set X, Y, Z by writing on magic mending tape)
9	several small paper cups; bowls and jars; a supply of rice, sand or macaroni
10	2 containers smaller than a liter, liter measure, 4-5 containers greater than a liter (label two A and B), water, bath towel or plastic dishpan suggested to catch spills
11	empty soda can, liter container, deciliter container, jar to calibrate in deciliters, magic mending tape, 8-10 containers to measure in deciliters (label two X and Y), centiliter container, meter, decimeter, centimeter
12	several deciliter containers (3 1/2 oz. Solo cups are okay), container calibrated in deciliters
13	none
14	three identical milk cartons, balance, a variety of objects to weigh, and two lumps of modeling clay or Playdoh

section number	materials description
15	balance, 15-20 pennies, box of paper clips, several small objects to weigh (label three 1, 2, and 3)
16	balance; gram weights; various items to weigh, including 3 objects labeled A, B, and C to weigh in grams; 1 pound box of raisins
17	gram weights, kilogram weight, balance, metric bathroom scale
18	5-6 Celsius thermometers, hot water, glass of ice cubes
19	centimeter rulers, cm tape measure on wall, cloth tape measures, bathroom scale, paper fasteners or staples

the 4th company

section 1 · length: comparison

Objectives: Given three straight objects that cannot be compared directly, determine the longest (or shortest) by using a reference object.

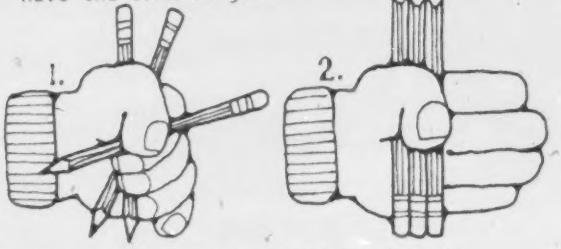
Given three non-straight objects (or curved lines), determine the longest (or shortest) by using a reference object.

Vocabulary: Same length

Materials: pencils (3 the same length, others different lengths), masking tape, string, strips of paper (activities 6 and 7)

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up three (figure 1.) pencils which are the same length and ask, "Are these pencils the same length? How can we tell for sure?" Then place them side by side with their ends even (figure 2.) to compare their lengths. Point out that all the pencils are even at both ends. This means the pencils have the same length.



2. Without letting the students see the pencils beforehand, take three pencils of differing lengths and arrange them in your hands so that the eraser ends are covered (in your hands) and the other ends are at the same height. Ask, "Do these pencils have the same length?" Hopefully the students will realize they cannot tell without seeing both ends. "Can you really tell? How could we check your guess?" Point out that we must always look at both sets of ends. Place them side by side as before to verify that they have different lengths.

3. Without letting the students see the pencils beforehand, hold three pencils with the same length in your hands so that the visible ends are not even. Ask, "Are these pencils the same length?" As before, point out that both ends must be compared. If there is interest, play a few rounds of "drawing straws". Arrange three pencils with different lengths so that one set of ends is hidden in your hands. Let three students each choose a pencil then compare their draws. The shortest pencil wins the draw.

4. Ask three students of nearly the same size to come forward. Have the class guess which one has the largest waist (is the biggest around the middle) and which one has the smallest waist. Discuss how the class could verify their guesses. If no one suggests it, introduce a piece of string. Wrap it around one student's waist and cut it off to just fit. Repeat with more string for each of the other two students. Then let them compare strings. Repeat with three or four students at a time until everyone has a string the length of his waist.

5. Using a string, demonstrate how to find the length around the wrist of a volunteer. Holding one end of the string on the student's wrist, wrap the string around until it meets the end. Pinch the string at this point. Explain that the length of string from the end to where you are pinching it represents the length around the student's wrist.

Then have your volunteer student find the length around your wrist. Hold up the two strings side by side to see whose wrist is the larger. Have the students pair off and each find the length around the wrist of his partner. Have each pair compare wrist lengths. Try to find who has the largest and smallest wrists in the class.

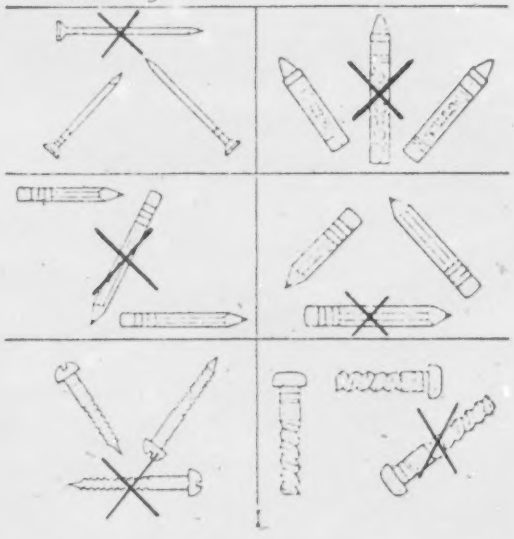
6. Before class cut three pieces of masking tape nearly the same length (eg. 18 cm, 20 cm, 21 cm) and tape them on opposite ends of the chalkboard vertically and along the bottom in the middle horizontally. Direct the students' attention to the three pieces of tape and ask, "If we cannot move the tape, can we tell which one is the longest? Can you think of a way to find the longest?"

   Two techniques should be illustrated: 1) cut a piece of string (or strip of paper) the same length as each piece of tape, then compare the strings (or strips); 2) select a strip of paper longer than the pieces of tape, lay it beside each piece of tape, mark its length on the paper, then compare marks.

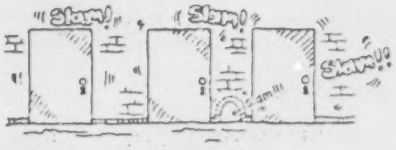
   To provide more practice with these techniques, draw three lines on the board and let students find the longest. Students can also be asked to compare the lengths around books and other objects in the classroom.

7. Discuss pages 1 and 2 and complete the exercises together. Each student will need both string and strips of paper. Demonstrate how to do the first problem on each page. For page 1, mark the lengths on a strip of paper. For page 2, curl string along the curved lines.

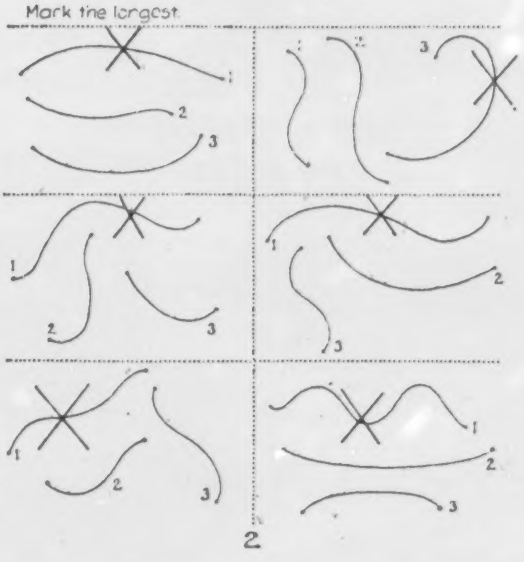
Mark the longest



1



Mark the largest



2

the 4th company

section 2 · length: arbitrary units

Objectives: Given an arbitrary unit of length, determine the length of an object to the nearest unit.

Vocabulary: steps, unit, guess, estimate

Materials: a long and a short pencil, children's crayons, 7-8 paper clips per student

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Demonstrate how to measure a desk using a long pencil. This will require some coordination on the part of the children, so demonstrate the procedure with care. Place the long pencil even with the end of the desk. Lay your right index finger at one end of the pencil. Keep finger in place while moving the pencil and keep count of the number of times you lay the pencil down. If the number is not exact, say something like, "The desk is about 8 pencils long." Write the measure on the board, following the format of page 1 of the student booklet.

   "about 8 pencils long"

   Then repeat with a short pencil and write the measure on the board. The idea of using two different pencils is to show that "pencil" does not always mean the same length and this can result in different answers.

2. Ask students to find a long crayon and have them measure the length of their desks with it and record their measurements on page 3. Then have the students repeat the exercise with a short crayon, again using page 3. The measures will vary, so have a brief discussion about the variation in the measures. "Crayons" are not good for measuring because they are not all the same size.

3. Walk across the room in tiny steps (heel to toe); ask, "Is that my normal walk?" Walk across the room in giant strides; ask, "Is that my normal walk?" Then walk normally across the room, counting your steps as you go. Write the result on the chalkboard:

   "28 steps"

   Have each child, one at a time, step off the length of the room. Record each student's name and number of steps on the board. To keep interest and order, have the class count each student's steps together. Have the class estimate before each student measures. Discuss why "steps" would not be a good unit for everyone to use.

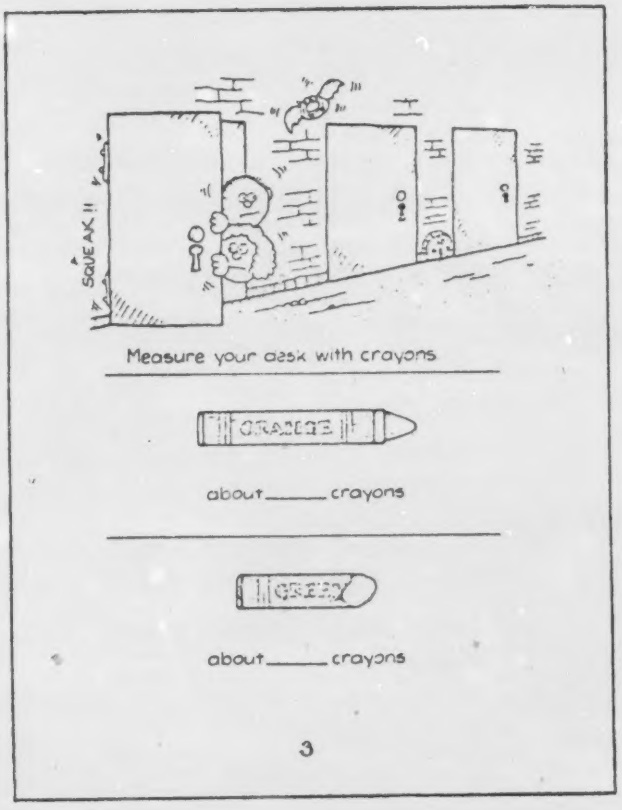
4. During the measuring tasks, if the measures are not exact, ask children to determine whether it is a "little more than" (or a "little less than") a given number of units. Record this as "about ____ units long". This is leading up to a more formal presentation of rounding off to the nearest whole unit. Keep it informal at this stage.

5. Select a distance (from 20 to 50 steps in length) and ask students to step it

off two ways, in their normal step and in a "giant" step.

6. Measure the length of the room in "people". Let students lie down on the floor, head to foot, across the room, count the number of people needed. Ask, "If you use grown up people, would it take more or fewer people?"

7. Discuss appropriateness of units: "Would you rather measure the playground using your steps as a unit or using your crayon as a unit? Which would be easier?"



the 4m company

section 3 · length: meter

Objectives: Given a meter stick, determine the length of an object to the nearest meter.

Spell "meter".

Vocabulary: meter, m

Materials: meter sticks with masking tape covering all printing and subdivisions, masking tape, adding machine tape

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Use the preceding section to introduce the need for a standard unit of length, a unit which people all over the world can use and which is always the same length. Point out that "steps" or "crayons" vary in length. Introduce the meter as a unit used all over the world to measure length and distances. Have students come forward one at a time. Compare their heights, then their armstretches, to the meter stick. Then place the meter stick on the floor and see if anyone has a "giant" step which is as long as a meter.

2. Discuss page 4, illustrating the proper way to measure using meter sticks.

3. Have students guess the length of the room in meters. "If placed end to end, how many meters would it take to go across the floor, from one wall to the other?" See if the class can find a solution using only 1 meter stick (as was done with the crayons). Demonstrate if necessary. Let 2 students measure the room as the rest of the class keeps track of the number of meter lengths. Then record the measurement on the board in two ways as illustrated. (Round off to the nearest whole meter.)

about ___ meters
about ___ m

Explain that meter can be spelled two ways, "meter" or "metre". But we will spell it "meter". Have the class spell it aloud looking at the board. Then have them cover their eyes and spell it aloud. Explain that "m" is the symbol for meter. It is always a little m with no period.

4. Tape 2 strips of masking tape on the floor for students to measure in meters. Label one strip X and one Y. Let students work in pairs to measure each strip of tape and record the lengths on page 5. Assign pages 6 and 7 for students to work on when not measuring. Explain directions as necessary.

5. Cut a strip of adding machine tape one meter long for each student in the class. Let the students help you and give them an opportunity to actually compare their own meter strip to a meter stick. Have students write their names on one side of their meter strips. On the same side have students write the following:

My room is ___ meters long.
My room is ___ meters wide.
My bed is ___ meters long.

As a homework assignment have students use their meter strips to make these measurements and complete the sentences. Have students save their meter strips to use in the next section.

6. Provide drill on spelling the word "meter" if it is necessary. Also, from time to time throughout the year assign pairs of students measuring tasks using meter sticks.

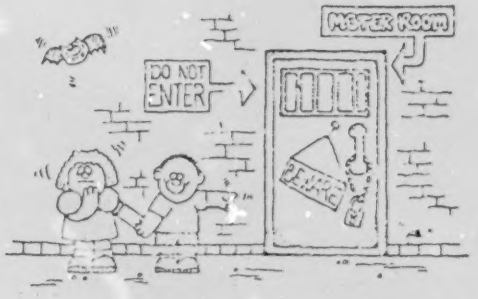
Which of these show the right way to measure?

No. There are gaps.

No. They overlap.

Yes

4



Use a meter. Measure the tapes on the floor. Write your answers here.

about _____ meters

about _____ meters

5

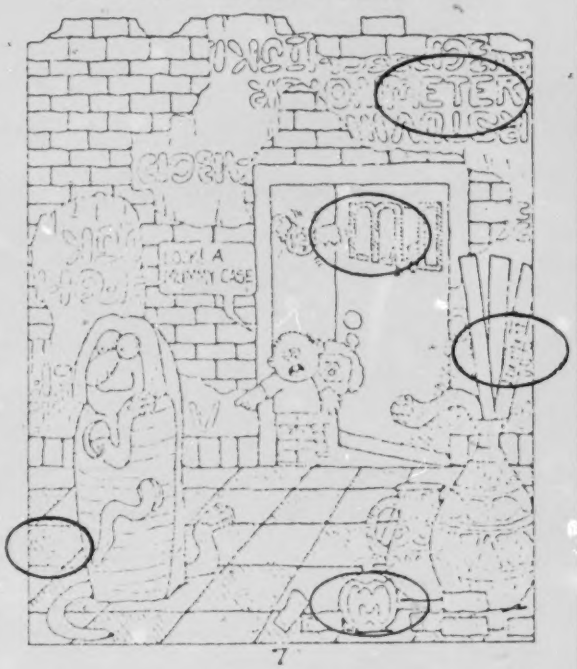
Trace the dotted lines. Then write meter and its symbol on your own.

meter m

meter *m*

6

There are 2 words and 3 symbols for meter hidden in the picture. Can you find them?



7

the 4m company

section 4 · length · decimeter

Objectives: Given a decimeter ruler, determine the length of an object (less than one meter) to the nearest decimeter.

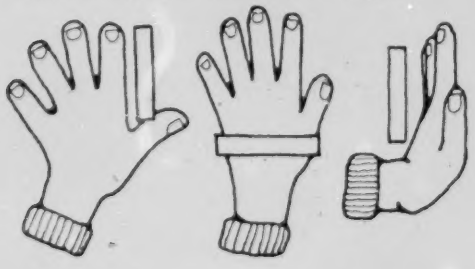
Vocabulary: decimeter, dm, ruler

Materials: meter stick with masking tape covering all marks, 10 decimeter strips (cut from back of Teacher's Guide), meter stick marked in decimeters, one meter long strip of adding machine tape, glue or tape

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up a plain meter stick (all markings covered). Ask the students if they could measure the width of one of their metric booklets using the meter stick. Have some students try to measure the width of their booklets with the meter stick. Ask, "How many meters wide is this book?" Demonstrate that the meter is much larger than the width of the book. Explain, "Because we cannot measure small things with a meter, we need a smaller unit of length." Hold up a decimeter strip. Explain, "This strip is one decimeter long. The decimeter is also a unit used to measure length. Its symbol is 'dm'." Write "decimeter" and "dm" on the board, explaining that "d" stands for "deci" and "m" stands for "meter".

2. Have students turn to the back of their books and cut out the ten decimeter strips provided there. Have students use one strip to find some part of their hand that is about 1 decimeter long.

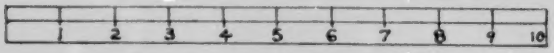


3. As a class activity, measure the length of a table top by laying dm strips end to end. Count the strips and write the measurement on the board. Round off to the nearest whole decimeter.

4. Have the students use the dm strips to find the width of their metric booklets. They are about 2 dm wide. Ask, "How many decimeters long do you think a meter is?" Line decimeter strips along a meter stick having the class keep count. Let the class examine a meter stick marked in decimeters and compare a dm strip to a decimeter on the meter stick. Count the 10 decimeters on the meter stick to emphasize 10 dm = 1 m.

5. Explain to the class that they are going to make a meter long tape marked in decimeters like the meter stick introduced in activity 4. Tape a one meter long strip of adding machine tape to the board and glue or tape one decimeter strip (cut from the back of the Teacher's Guide) along the top edge flush with the left end. Glue or tape a second decimeter along the top edge flush with the end of the first decimeter. Tape on the rest of the decimeter strips pointing out to the class the importance of lining them up along the top edge and of leaving no gaps or overlaps between.

Now number each decimeter below its right edge from 1 to 10.



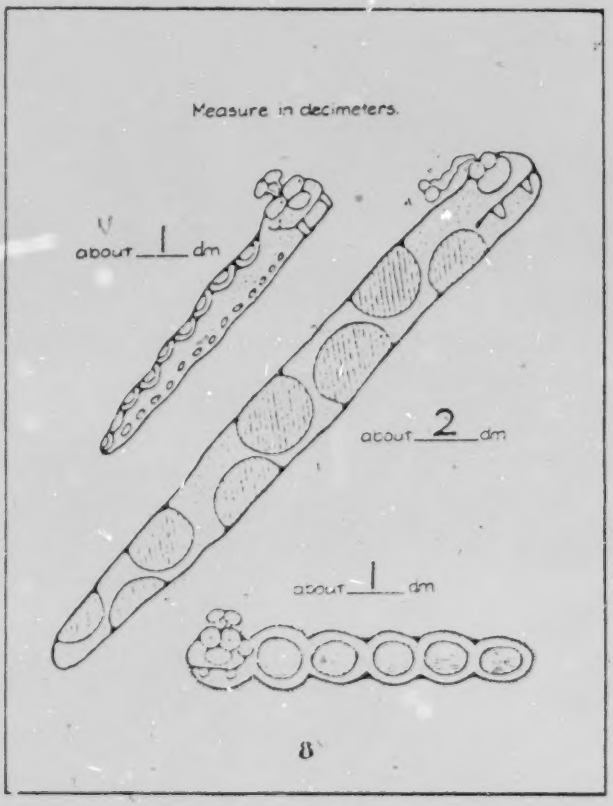
Have students take out their meter strips (from Section 3) and glue or tape their 10 decimeter strips to the blank side. Have them number the strips as you did at the board. Supervise their construction since these rulers will be used for subsequent measuring activities.

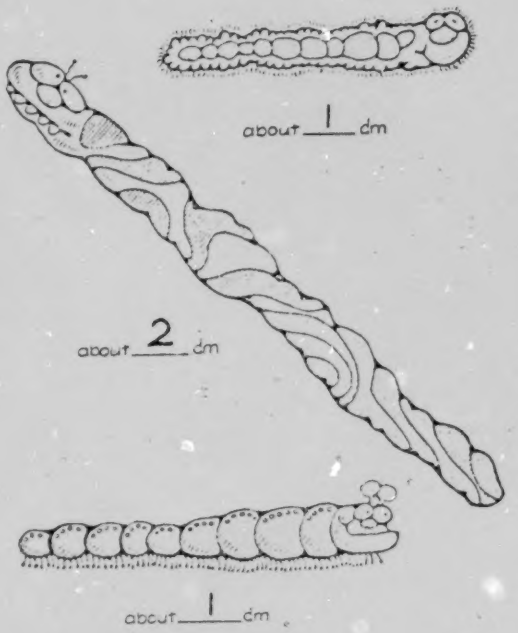
6. To build estimation skills, have the students use the part of their hands they found to be 1 dm long to help them guess the length of their desk tops in dm. Then let them measure it with the rulers they just made. Draw a line 1 dm long on the board, then draw several other lines (perhaps 2, 5 and 8 dm long). Ask the students to estimate the lengths of the lines using the 1 dm line as a guide. Then measure the lines with a meter strip marked in decimeters, demonstrating proper technique and rounding off. A note about guessing: Guesses at first will be way off. This is to be expected. The students' guessing should improve with practice. When you ask the class to guess a measurement write a few guesses on the board (with unit labels), and make a guess yourself. After the actual measurement is made, praise close guessers, encourage all guessers, and erase the guesses (so "wrong" guesses do no haunt anyone). Make a few bad guesses yourself to help remove the fear of guessing wrong. The goal for the students is to make close guesses; exact guesses are not to be expected.

7. Assign pages 8 and 9. Have each student use a piece of scratch paper and record a guess before measuring each picture. Let them discard their guesses. Have them round off their measurements to the nearest whole decimeter.

8. Assign pages 10, 11, and 12. While students work on pages 11 and 12 at their seats, have one or two students at a time complete the measuring tasks on page 10. This should serve as a check-up to see if all students can measure correctly.

9. Play the following game: Ask three students to draw a line segment which they think is 3 dm long on the chalkboard. The rest of the class then votes for the one they think is nearest to 3 dm in length. Three students then come forward and use their dm rulers to measure each line segment. The student whose line segment was nearest to 3 dm can then choose three new contestants to draw line segments of a given length. This procedure may be repeated many times or the idea adapted to use teams. Play this throughout the year to practice estimation skills.





about 1 dm

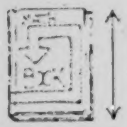
about 2 dm

about 1 dm

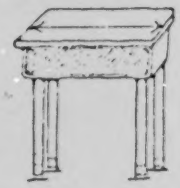
9

Measure these objects in your classroom.

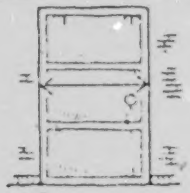
about ____ dm



about ____ dm



about ____ dm



about ____ dm

10

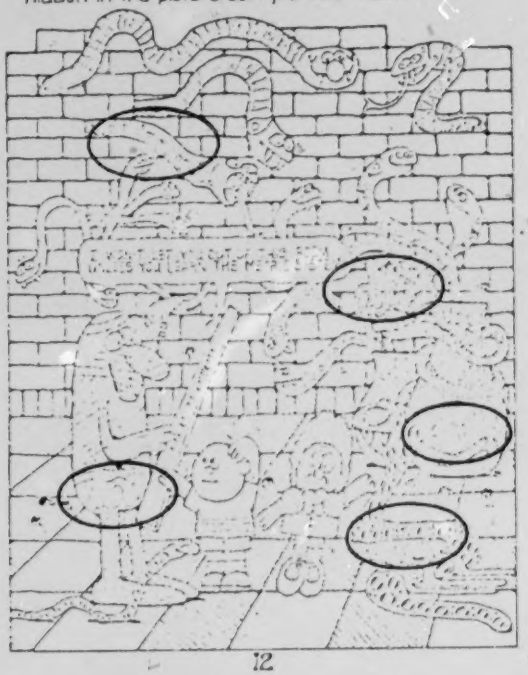
Trace the dotted lines. Then write decimeter and its symbol on your own.

decimeter dm

decimeter dm

11

There are 2 words and 3 symbols for decimeter hidden in the picture. Can you find them?



12

the 4th company

section 5 · length: centimeter

Objectives: Given a centimeter ruler, determine the length of an object to the nearest centimeter.

Vocabulary: centimeter, cm

Materials: plain meter stick; decimeter ruler; centimeter unit (cm cube or unit cut from back of Teacher's Guide); cm ruler (cut from back of Teacher's Guide); 6 cards and a marker to make flashcards (activity 8); dm strip (cut from back of Teacher's Guide)

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up a short crayon (less than 5 cm long) and ask, "If we wanted to measure the length of this crayon, could we measure it with meters?" Hold up a plain meter stick next to the crayon. Through discussion bring out that the meter is too long to measure the crayon. Then hold up a decimeter ruler and ask, "Could we measure it with a decimeter ruler? How many decimeters long is the crayon?" Again, point out that the unit is too long. Introduce the centimeter. "People all over the world use the centimeter unit to measure short things like our crayon." Write "centimeter" on the chalkboard. Ask, "Does anyone see a familiar word hidden in this new word?" Point out "meter" in centimeter. "The name of the centimeter unit tells us that it has something to do with the meter. In fact, the people who invented the meter had the same problem we had when we wanted to measure short things. So they cut a meter into exactly 100 parts to make centimeters." Display a cm unit (cm cubes or units cut from the back of the Teacher's Guide). And explain that it is exactly 1 centimeter long and that if we lined up 100 centimeters we would have exactly 1 meter. Display a meter stick calibrated in centimeters.

   Introduce the symbol for centimeter by reviewing symbols for meter and decimeter and letting students try to guess that the symbol for centimeter is "cm". The "c" stands for "centi" and the "m" stands for "meter".

2. Demonstrate how to measure using a centimeter ruler (cut from the back of the Teacher's Guide). Draw a line on the chalkboard and carefully line up the end of the ruler with the end of the line. Count over the number of centimeter units one by one and verify that the number on the ruler agrees with the number of units you counted. Have students cut out their centimeter rulers from the back of their books.

3. Work through page 13 as a class. Have students take out a sheet of scratch paper and assign pages 14 and 15. They are to guess the length in centimeters of each picture and write that guess on their scratch paper, then measure the picture. After they measure, have them check to see how close their guess was. Have them try to improve their guesses so they can guess within 2 or 3 cm of the actual length. Let them discard their scratch paper.

4. Demonstrate how to measure an <u>object</u> with a centimeter ruler, lining up the end of the ruler with the end of the object. If the object is not an exact number of centimeters have students record the number it is closer to. (If it is just half way between we usually round off to the higher number.) Keep rounding off at an informal level; accept errors and use "about" to

indicate the approximate nature of your measurements.

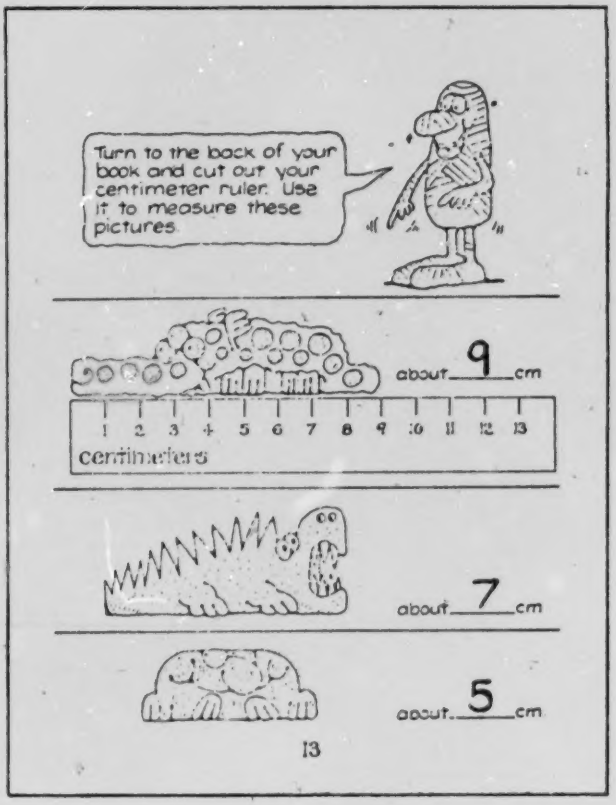
5. Assign pages 16 and 17. While the class works on page 17, direct small groups of students through page 16. Have them measure the items in the classroom pictured on the page. Check measuring and rounding technique.

6. Play the following game: Ask three students to draw a line segment which they think is 20 cm long on the chalkboard. The rest of the class then votes for the one they think is nearest to 20 cm in length. Three students then come forward and use their cm rulers to measure each line segment. The student whose line segment was nearest to 20 cm can then choose three new contestants to draw line segments of a given length. This procedure may be repeated many times or the idea adapted to use teams. Play this throughout the year to practice estimation skills.

7. Make 6 flashcards, one with each of the following written on it: meter, m, decimeter, dm, centimeter, cm. Place a meter, a decimeter, and a centimeter on a table. Ask the class to identify by naming the longest, shortest, and in-between. Have a student match the cards to the units. Have a student order the flashcards from smallest to largest. Hold up a card and have the class identify the unit and show with their hands about how long that unit is. Use the cards and these activities periodically throughout the year to reinforce vocabulary and size relationships of metric units.

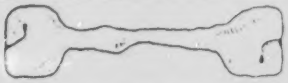
8. Explain to the class that centimeters and meters are used most often to measure lengths - the meter for long lengths, the centimeter for short lengths. Ask, "If you were to measure the length of the playground which would you use, meters or centimeters?" Repeat this oral exercise asking which unit - meters or centimeters - to use to measure things like the following:

   your hand
   a car
   a football field
   a desk top
   the length of a room
   a book
   your height

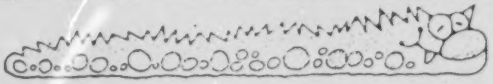

Turn to the back of your book and cut out your centimeter ruler. Use it to measure these pictures.
about 9 cm
1 2 3 4 5 6 7 8 9 10 11 12 13
centimeters
about 7 cm
about 5 cm
13

Measure these

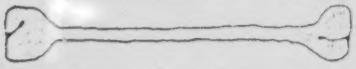
about 11 cm



about 8 cm



about 14 cm



about 10 cm

about 9 cm

14

Help measure these rats

about 8 cm

about 4 cm

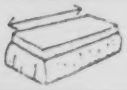
about 6 cm

about 10 cm

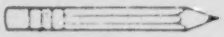
about 9 cm

15

about ____ cm



about ____ cm



about ____ cm

about ____ cm

about ____ cm

16

Trace the dotted lines. Then write centimeter and its symbol on your own.

centimeter cm

centimeter cm

17

the 4m company

section 6 · add units of length

Objectives: Given two expressions involving meters, add and label the sum (sums to ten).

Given two expressions involving decimeters, add and label the sum (sums to ten).

Given two expressions involving centimeters, add and label the sum (sums to ten).

Vocabulary: meters (m), decimeters (dm), centimeters (cm), add, sum

Materials: meter stick, dm ruler, cm ruler, adding machine tape

SUGGESTED PROCEDURE AND ACTIVITIES:

The purpose of this section is not to teach computation. This should be done in the regular math program. Instead, this section illustrates how addition can be applied to measurement.

1. Meters. Measure and cut two pieces of adding machine tape, one 2 meters long and the other 3 meters long. Tape them, (one under the other) on the board. Have a student use a meter stick to find their lengths. Write each measurement on the corresponding strip. Ask, "If we placed these end to end, how long would they be together?" Remove the strips from the board, tape them end to end on the floor, then have a student measure their total length. Record the procedure on the board:

$$\begin{array}{r} 2\,m \\ +3\,m \\ \hline 5\,m \end{array}$$

Point out to the class that in the problem we added meters so our answer is in meters, and we must label it. Explain that a measurement has two parts - a number and a unit.

Do several problems on the board, explaining that adding meters is just like adding regular numbers. Stress the importance of writing the unit (m).

2. Decimeters. Cut off 2 strips of adding machine tape, one 3 decimeters long, one 5 decimeters long. As a class demonstration, let a student measure each strip; record the measures on the board. Ask, "How long a strip could I make if I taped the two strips end to end?" Tape them together (without overlap) and let a student measure the resulting strip with his dm ruler. Write the addition problem just illustrated on the board.

$$\begin{array}{r} 5\,dm \\ +3\,dm \\ \hline 8\,dm \end{array}$$

Write several problems on the board. Ask for answers and discuss. Remind students that dm is the symbol for decimeter.

3. Centimeters. Write a problem such as

$$\begin{array}{r} 3\,cm \\ +4\,cm \end{array}$$

on the board. Cut a strip of paper 3 cm long and another 4 cm long. Ask how long they would be if placed end to end. Tape them end to end and measure the resulting strip with a cm ruler. Write the answer.

$$\begin{array}{r} 3\,cm \\ +4\,cm \\ \hline 7\,cm \end{array}$$

4. Write these three problems on the board:

$$\begin{array}{rrr} 4\text{m} & 4\text{dm} & 4\text{cm} \\ +2\text{m} & +2\text{dm} & +2\text{cm} \\ \hline \end{array}$$

Ask the class to solve each. Ask, "Which answer is the longest length? Which is the shortest? Show this length (6 cm) with your hands. Show this length (6 dm) with your hands. Are the three answers the same? No." Explain that they are not the same. 5 m, 5 dm, and 5 cm are all different lengths. Even though they all have "5", the unit is part of the answer, too. In a measurement the number without the unit is incomplete.

5. Assign page 18. Point out that the first row involves meters, the second row decimeters, and the third row centimeters. Caution students to label their answers with the correct unit. If a student gets the correct numerical answer but forgets the unit, do not count it wrong. Rather, tell the student it is incomplete.

6. Have students take out a sheet of paper. Explain that you are going to read some measurement stories. On their blank paper they are to write and solve the problems involved. Do a problem or two on the board first. The following six story problems may be used for this activity. Substitute and add to these as needed. You may want to let students act out each story problem.

i. Dr. Franken has two ropes. One is 6 meters long. The other is 4 meters. How long are both ropes together?

ii. Jim has a string 5 decimeters long. Jane has a string 2 decimeters. How long are both strings together?

iii. Igor kicked a can 7 meters. He kicked it again and it went 2 meters. How far did Igor kick the can altogether?

iv. Meter Mummy stepped 6 centimeters, then stepped 4 centimeters. How far did he step altogether?

v. How much is 8 meters and 2 meters?

vi. If Jim has 6 decimeters and Jane has 3 decimeters, how many decimeters do they have together?

Let's add meters.
Label your answers.

$\begin{array}{r} 2\text{m} \\ +3\text{m} \\ \hline \end{array}$	$\begin{array}{r} 5\text{m} \\ +5\text{m} \\ \hline \end{array}$	$\begin{array}{r} 3\text{m} \\ +4\text{m} \\ \hline \end{array}$	$\begin{array}{r} 6\text{m} \\ +3\text{m} \\ \hline \end{array}$	$\begin{array}{r} 4\text{m} \\ +4\text{m} \\ \hline \end{array}$	$\begin{array}{r} 3\text{m} \\ +5\text{m} \\ \hline \end{array}$
5m	10m	7m	9m	8m	8m

Let's add decimeters.
Label your answers.

$\begin{array}{r} 3\text{dm} \\ +1\text{dm} \\ \hline \end{array}$	$\begin{array}{r} 2\text{dm} \\ +5\text{dm} \\ \hline \end{array}$	$\begin{array}{r} 4\text{dm} \\ +5\text{dm} \\ \hline \end{array}$	$\begin{array}{r} 8\text{dm} \\ +2\text{dm} \\ \hline \end{array}$	$\begin{array}{r} 5\text{dm} \\ +3\text{dm} \\ \hline \end{array}$	$\begin{array}{r} 2\text{dm} \\ +4\text{dm} \\ \hline \end{array}$
4dm	7dm	9dm	10dm	8dm	6dm

Let's add centimeters.
Label your answers.

$\begin{array}{r} 4\text{cm} \\ +6\text{cm} \\ \hline \end{array}$	$\begin{array}{r} 2\text{cm} \\ +2\text{cm} \\ \hline \end{array}$	$\begin{array}{r} 1\text{cm} \\ +7\text{cm} \\ \hline \end{array}$	$\begin{array}{r} 3\text{cm} \\ +3\text{cm} \\ \hline \end{array}$	$\begin{array}{r} 6\text{cm} \\ +2\text{cm} \\ \hline \end{array}$	$\begin{array}{r} 5\text{cm} \\ +4\text{cm} \\ \hline \end{array}$
10cm	4cm	8cm	6cm	8cm	9cm

18

the 4m company

section 7 · subtract units of length

Objectives: Given two expressions involving meters, subtract and label the difference (minuends to ten).

Given two expressions involving decimeters, subtract and label the difference (minuends to ten).

Given two expressions involving centimeters, subtract and label the difference (minuends to ten).

Vocabulary: meters (m), decimeters (dm), centimeters (cm), subtract, difference

Materials: adding machine tape, dm ruler

SUGGESTED PROCEDURE AND ACTIVITIES:

The purpose of this section is not to teach computation, but rather to apply subtraction to measurement situations.

1. Cut a piece of adding machine tape 6 dm long. Have a student measure it. Then ask, "If I cut off 2 decimeters, how much would be left?" Measure and cut off 2 decimeters. Let a student measure the remaining piece. Write

$$\begin{array}{r} 6\,dm \\ -\,2\,dm \\ \hline 4\,dm \end{array}$$

on the board. Explain that subtracting measurement expressions is just like subtracting regular numbers, except that we must always include the unit: m, dm, or cm. If you think it is necessary, illustrate subtraction of meters and centimeters using lengths of adding machine tape.

2. Write these three problems on the board:

$$\begin{array}{r} 7m \\ -\,2m \\ \hline \end{array} \qquad \begin{array}{r} 7dm \\ -\,2dm \\ \hline \end{array} \qquad \begin{array}{r} 7cm \\ -\,2cm \\ \hline \end{array}$$

Ask the class to solve each. Ask, "Which answer is the longest length? Which is the shortest? Show this length (5 cm) with your hands. Show this length (5 dm) with your hands. How long is this length (5 m)? These three answers all have a '5'. Are they the same?" Review the importance of the unit label.

3. Assign page 19. The first row involves meters, the second decimeters, and the third centimeters. As with addition, stress the importance of the proper unit.

4. Read story problems involving subtraction and have students solve them at their desks. Work a problem or two on the board. The follwoing story problems may be used for this activity.

   i. A piece of tape is 9 centimeters long. Jim cuts off 2 centimeters. How much is left?

   ii. Dr. Franken has a rope 10 meters long. He chops off 2 meters of it. How much rope is left?

   iii. Meter Mummy has a piece of cloth 5 meters long. He cuts off 4 meters. How much cloth does he have left?

   iv. Jim had a piece of licorice which was 8 centimeters long. He gave Jane 4 centimeters of the licorice. How much did Jim have left?

   v. Igor had a whip which was 5 meters long. 1 meter of it broke off. How long was his whip?

Let's subtract meters.
Label your answers.

6m − 3m	7m − 2m	8m − 6m	5m − 3m	4m − 2m	8m − 4m
3m	5m	2m	2m	2m	4m

Let's subtract decimeters.
Label your answers.

9dm − 5dm	8dm − 3dm	7dm − 4dm	6dm − 2dm	5dm − 2dm	4dm − 3dm
4dm	5dm	3dm	4dm	3dm	1dm

Let's subtract centimeters.
Label your answers.

10cm − 4cm	9cm − 6cm	8cm − 2cm	7cm − 5cm	10cm − 3cm	9cm − 4cm
6cm	3cm	6cm	2cm	7cm	5cm

the 4th collpany

section 8 · capacity: comparison

Objectives: Given two equal amounts of liquid, state that the amounts remain equal when one of them is poured into a different-shaped container. (Mastery not expected of all children at this age level.)

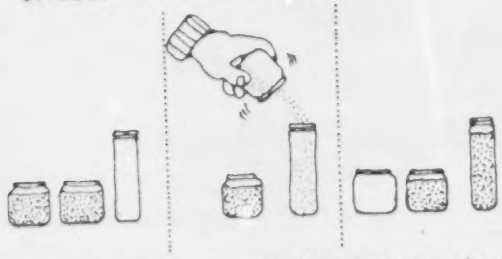
Given three containers of different shapes, determine which holds the most (or least) by using a reference container.

Vocabulary: holds more, holds less, holds most, holds least

Materials: two identical transparent containers (baby food jars are good), 1 tall thin container (stuffed olive jar is good), 1 short wide container, water (colored water works well), large jar or pitcher to use as a reference container, magic mending tape, 3-4 sets of 3 containers of different shapes but nearly the same size (label one set 1, 2, 3; one set A, B, C; one set X, Y, Z by writing on magic mending tape)

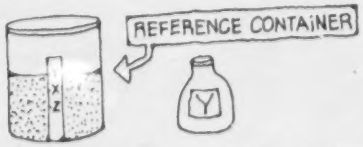
SUGGESTED PROCEDURE AND ACTIVITIES:

1. Put the same quantity of water into two identical containers. Ask the students if they contain the same quantity of water. Pour the contents of one into the tall, skinny container. Ask if the two containers have the same amount of water in them. Pour the contents of the tall skinny container back into the original container to show that the amount of liquid is indeed the same. Explain that even though the containers are different shapes and sizes, the amount of water does not change.



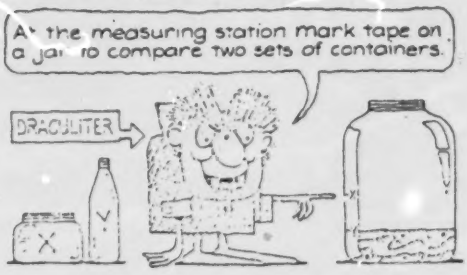
2. Repeat the same procedure using a short, wide container. The purpose is to illustrate that the amount of water remains the same when poured into different shaped containers.

3. Demonstrate how to use a reference container to determine which of three containers holds the most. Use a large jar with a strip of magic mending tape along the side. Fill one of the three containers (labeled X) with water. Pour it into the jar and mark the water level. Label it X. Repeat with the other two containers, labeling their marks Y and Z. The container whose mark is highest holds the most liquid. Repeat with three other containers if necessary, letting students participate.



4. Set up two stations with a reference container, tape, and 3 containers at each. Label one set 1, 2, and 3, the other set A, B, and C (mark on magic mending tape to label the containers). Let students work in pairs to complete the two activities on page 20. Have each pair remove their tape from the reference container when they finish at that station.

Meanwhile, inside the Liter Room...



1. Circle the one that holds the most

container 1
container 2
container 3

2. Circle the one that holds the least

container A
container B
container C

20

the 4M company

section 9 · capacity: arbitrary units

Objectives: Given an arbitrary unit container, determine the capacity of a container to the nearest unit.

Vocabulary: capacity

Materials: several small paper cups; bowls and jars; a supply of rice, sand or macaroni

SUGGESTED PROCEDURE AND ACTIVITIES:

For the demonstration it may be more effective and manageable to seat the students on the floor near a low demonstration table. When student participants come forward, have them step behind the table so the others can see what is happening. As much as possible use clear containers in demonstrations for the class.

1. Use a paper cup and small bowl to to demonstrate how to determine the number of cupfuls of rice (sand or macaroni) it takes to fill a larger container. Point out the need to always fill the cup to the top and to level the contents. Use another bowl or large-mouthed jar and ask students to guess how many cupfuls of rice it will hold. Write some guesses on the board. Then select one guess and ask that number of students to come forward to each place a cupful of rice in the jar. Give each student a paper cup. Ask the class to watch to make sure each cup is filled properly and to keep count. When the jar has been filled, write the measurement on the board.

   Repeat the guessing and measuring procedure using other containers. Try to allow each child a measuring experience.

2. Set out a paper cup, rice, and liter container. While the other students are at their seats, check out one student at a time, making sure that he knows the technique for measuring. That is, filling the cup to the top, pouring it into the liter container, and keeping count of the number of cups.

the 4th collpony

section 10 · capacity: liter

Objectives: Given a liter measure, determine the capacity of a container to the nearest liter.

Spell "liter".

Vocabulary: ℓ (symbol for liter), capacity, liter

Materials: 2 containers smaller than a liter, liter measure, 4-5 containers greater than a liter (label two A and B), water, bath towel or plastic dishpan suggested to catch spills

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Write "liter" and its symbol "ℓ" on the board. (Also write "litre" and explain that this spelling is sometimes used). Introduce the liter as a unit of liquid measure which is used by people all over the world. Show a liter container, fill it with water (colored) to the line, and explain, "This much water, to this line, is a liter of water". Hold up a container and ask, "Do you think this container holds more or less than one liter of water?" Fill the liter container with water and pour it into the other container. Point out that if there is some water left in the liter, then the container holds less than one liter; if the water all fits into the container with no room leftover, then the container holds one liter; and if there is still room left in the container, then it holds more than one liter. Repeat with another container.

2. Use page 21 to discuss the proper way to measure with a liter container. Illustrate with water and a liter container.

3. Hold up a container much larger than a liter and have the children guess how many liters of water the container will hold. Demonstrate how to find the capacity of the container by using a liter measure. Fill the liter measure to its mark and pour its contents into the larger container. Repeat until the larger container is filled. Count the number of liters and summarize the experiment by saying, "This container will hold about 3 liters of water."

4. Pages 22 - 24 are to be completed as seatwork while you supervise the measuring activity on page 25. For page 25 set up a measuring station near a water source. You need a liter measure and two containers labeled A and B to be measured in liters. Supervise students two at a time. Have each student guess the capacity before measuring it and recording it on page 25.

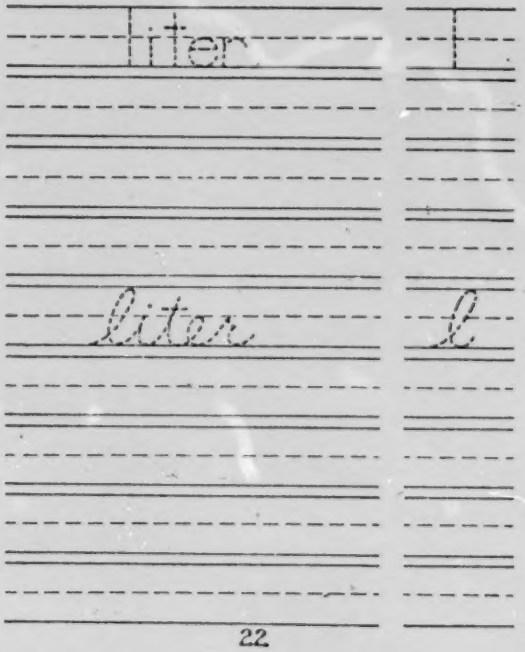
   Page 24 is a secret code. Children are to add expressions, find the letter which corresponds to the sum, and write that letter in the box below.

5. Review pages 22 and 24. Have students close their eyes and spell "liter" aloud several times. Then check the secret code.

Which of these shows the right way to measure with liters?

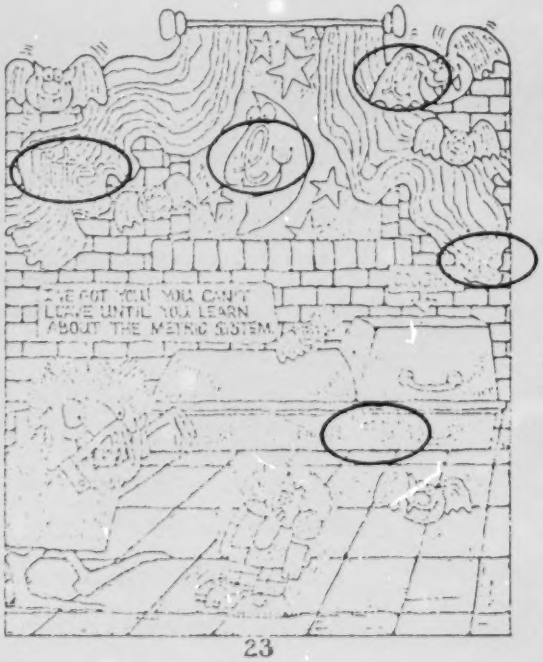
21

Trace the dotted lines. Then write liter and its symbol on your own.



22

There are 2 words and 3 symbols for liter hidden in the picture Can you find them?



23

Secret Code

2	3	4	5	6	7	8	9
L	E	S	T	A	R	I	N

$\frac{4}{-2}$ $\frac{10}{-2}$ $\frac{3}{-3}$ $\frac{6}{-3}$ $\frac{9}{-2}$ $\quad$ $\frac{4}{+4}$ $\frac{2}{+2}$

2 8 5 3 7 $\quad$ 8 4

L I T E R $\quad$ I S

$\frac{4}{+5}$ $\frac{2}{+1}$ $\frac{3}{+3}$ $\frac{3}{+2}$ $\frac{0}{+3}$ $\frac{5}{+2}$

9 3 6 5 3 7

N E A T E R

24

Capacity of container A about _____ liters

Capacity of container B about _____ liters

25

the 4th company

section 1 · capacity: deciliter

Objectives: Given a container calibrated in one deciliter intervals, determine the capacity of a container to the nearest deciliter.

Vocabulary: deciliter, dl, dℓ, centiliter, capacity

Materials: empty soda can, liter container, deciliter container, jar to calibrate in deciliters, magic mending tape, 8-10 containers to measure in deciliters (label two X and Y), centiliter container, meter, decimeter, centimeter

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up to the class a liter measure and an empty soda can. Ask, "How many liters of water will this can hold?" Discuss the inappropriateness of the liter as a unit for measuring small containers. Remind the students that to measure short lengths, the meter was divided into 10 parts called decimeters. Hold up a deciliter container. "This is a deciliter. Is it smaller or larger than a liter?" Hold the ℓ and dℓ side by side and explain, "Just as there are 10 decimeters in a meter, there are 10 deciliters in a liter." Write "deciliter" and its symbol on the board ("dℓ" and "dl" are both acceptable). Show with water that 10 dℓ is one liter. Ask the class to guess how many dℓ the soda can will hold. Then fill it with water and pour out one dℓ at a time while the class keeps count. It will hold a little more than 3 dℓ of water.

2. As a class demonstration calibrate a jar in deciliters. Put a strip of magic mending tape along the side of a jar. Fill a deciliter container; have the class agree that you have one deciliter of water. Pour it into the jar, and mark the water level. Label the mark "1 dℓ". Fill the deciliter container again. Add that deciliter of water to the one already in the jar. Mark the water level and label it "2 dℓ". Repeat the procedure to calibrate the whole jar.

Use the soda can from activity 1 to demonstrate how to measure capacity in deciliters using the calibrated jar. Fill the can with water, pour it into the jar and round off the measure to the nearest deciliter.

3. Collect a variety of containers smaller than a liter. As a group activity, have students estimate the capacity of a container in deciliters, then let a student come forward, fill the container, and pour it into the deciliter measure. If you repeat this several times it will provide good practice at estimation and measuring.

4. Set up a measuring station near a source of water. You will need the jar calibrated in deciliters and two containers labeled X and Y to be measured in deciliters. Supervise pairs of students as they measure the containers, round off the measures to the nearest deciliter, and record them on page 28. Pages 26 and 27 are to be done while students wait their turn at the measuring station.

5. Review the metric units studied so far. Write "meter", "decimeter", and "centimeter" on the board. Explain that these units are used to measure

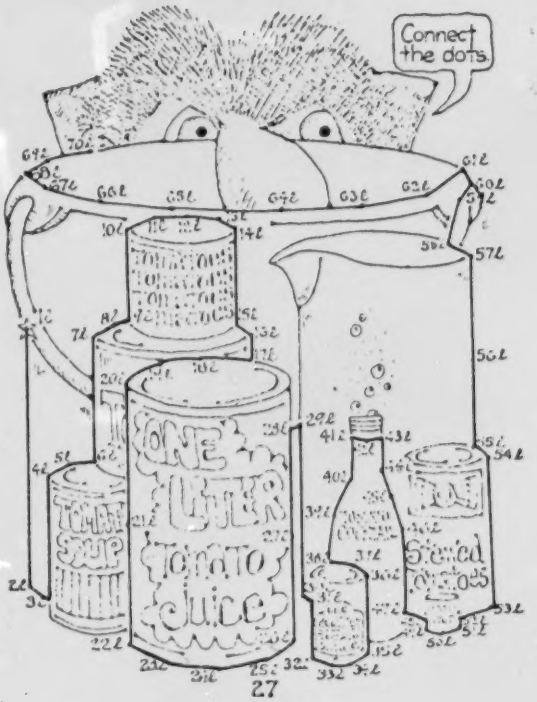
how long something is (length). Ask which is largest, which is smallest. Have students show each unit length with their hands. Write "liter" and "deciliter" on the board. Explain that these units are used to measure how much a container can hold (capacity). Ask which is larger, which is smaller. Display a meter, a decimeter, and a centimeter. Review 10 dm = 1 m and 100 cm = 1 m. Display a liter, a deciliter, and a centiliter. Explain that just as there are 10 decimeters in a meter, there are 10 deciliters in a liter. Introduce the centiliter, write "centiliter" on the board. Ask them to guess how many centiliters in a liter. Explain that we rarely use centiliters but it is a metric unit of capacity. Assign page 29.

Trace the dotted lines. Then write deciliter and its symbol on your own.

deciliter dl

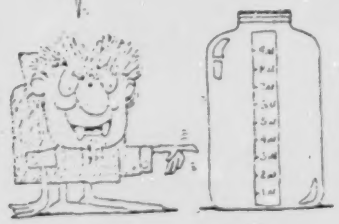
deciliter dl

26



27

Use a jar calibrated in deciliters to measure two containers. Record here.

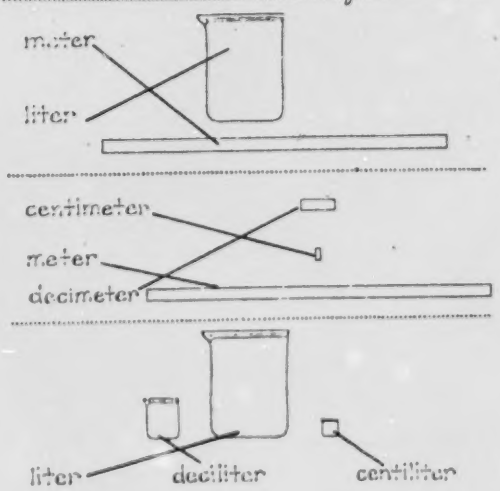


container holds ____ deciliters

container holds ____ deciliters

28

Draw lines to match the unit with its picture.



29

the 4th collpany

section 12 · add units of capacity

Objectives: Given two expressions involving liters, add and label the sum (sums to ten).

Given two expressions involving deciliters, add and label the sum (sums to ten).

Given two expressions involving centiliters, add and label the sum (sums to ten).

Vocabulary: liter, ℓ, deciliter, dℓ, centiliter, cℓ, add, sum

Materials: several deciliter containers (3 1/2 oz. Solo cups are okay), container calibrated in deciliters

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Introduce adding liters by posing a problem. "Your mother bought 2 liters of milk on Monday and 3 liters of milk on Tuesday. How many liters of milk did she buy altogether?" Write the problem on the board. Draw pictures to illustrate it if necessary. Remind students that the answer is "5 liters" not just "5". Point out the symbol "ℓ" for liter written in the answer.

$$\begin{array}{r} 2\ell \\ +3\ell \\ \hline 5\ell \end{array}$$

2. "If John has 2 deciliters of soda and Mary has 1 deciliter of soda, how many deciliters of soda do they have together?" Write

$$\begin{array}{r} 2\,d\ell \\ +1\,d\ell \\ \hline \end{array}$$

on the board. Hold up 2 Solo cups, then 1 more. Fill them with water and pour them into the container marked in deciliters. Observe that the water line comes up to the 3 dℓ mark. "There are 3 deciliters altogether." Write the sum on the board.

$$\begin{array}{r} 2\,d\ell \\ +1\,d\ell \\ \hline 3\,d\ell \end{array}$$

Repeat with other examples.

3. Similarly, explain that centiliters can also be added. Work one example on the board.

4. Then assign page 30. The first row involves liters, the second row deciliters, and the third row centiliters. Remind students to label their answers. Do not count an answer wrong if it is numerically correct but lacks a label. Ask the student to complete the answer.

5. Make up a simple word problem involving addition of metric units of capacity. Solve it on the board. Then ask students to make up word problems for the class to solve.

$\begin{array}{r} 2\,\ell \\ +2\,\ell \\ \hline \end{array}$	$\begin{array}{r} 4\,\ell \\ +5\,\ell \\ \hline \end{array}$	$\begin{array}{r} 5\,\ell \\ +3\,\ell \\ \hline \end{array}$	$\begin{array}{r} 3\,\ell \\ +4\,\ell \\ \hline \end{array}$	$\begin{array}{r} 8\,\ell \\ +1\,\ell \\ \hline \end{array}$	$\begin{array}{r} 7\,\ell \\ +3\,\ell \\ \hline \end{array}$
$4\,\ell$	9ℓ	8ℓ	7ℓ	9ℓ	10ℓ
$\begin{array}{r} 3\,d\ell \\ +3\,d\ell \\ \hline \end{array}$	$\begin{array}{r} 4\,d\ell \\ +2\,d\ell \\ \hline \end{array}$	$\begin{array}{r} 5\,d\ell \\ +2\,d\ell \\ \hline \end{array}$	$\begin{array}{r} 6\,d\ell \\ +3\,d\ell \\ \hline \end{array}$	$\begin{array}{r} 8\,d\ell \\ +2\,d\ell \\ \hline \end{array}$	$\begin{array}{r} 5\,d\ell \\ +5\,d\ell \\ \hline \end{array}$
$6\,d\ell$	$6\,d\ell$	$7\,d\ell$	$9\,d\ell$	$10\,d\ell$	$10\,d\ell$
$\begin{array}{r} 6\,cl \\ +2\,cl \\ \hline \end{array}$	$\begin{array}{r} 5\,cl \\ +1\,cl \\ \hline \end{array}$	$\begin{array}{r} 7\,cl \\ +2\,cl \\ \hline \end{array}$	$\begin{array}{r} 1\,cl \\ +6\,cl \\ \hline \end{array}$	$\begin{array}{r} 2\,cl \\ +3\,cl \\ \hline \end{array}$	$\begin{array}{r} 4\,cl \\ +3\,cl \\ \hline \end{array}$
$8\,cl$	$6\,cl$	$9\,cl$	$7\,cl$	$5\,cl$	$7\,cl$

30

41

the 4th company

section 13 · subtract units of capacity

Objectives: Given two expressions involving liters, subtract and label the difference (minuends to ten).

Given two expressions involving deciliters, subtract and label the difference (minuends to ten).

Given two expressions involving centiliters, subtract and label the difference (minuends to ten).

Vocabulary: liter (ℓ), deciliter (dℓ), centiliter (cℓ), subtract, difference

Materials: none

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Fill the container marked in deciliters with 6 dℓ of water. "If I take away 2 deciliters of this water, how much will be left?" Write

$$\begin{array}{r} 6\,d\ell \\ -\,2\,d\ell \\ \hline \end{array}$$

on the board. Let the students guess. Then pour water from the container into 2 Solo cups (dℓ containers) and observe how much is left in the large container. Write the difference on the board.

$$\begin{array}{r} 6\,d\ell \\ -\,2\,d\ell \\ \hline 4\,d\ell \end{array}$$

Repeat with other examples.

2. Explain that subtraction of any metric measurements, liters, deciliters, or centiliters, is just like subtraction of regular numbers, except that we must remember to label the answer. To reinforce the need for labeling, write three problems on the board.

$$\begin{array}{r} 4\,\ell \\ -\,3\,\ell \\ \hline \end{array} \qquad \begin{array}{r} 4\,d\ell \\ -\,3\,d\ell \\ \hline \end{array} \qquad \begin{array}{r} 4\,c\ell \\ -\,3\,c\ell \\ \hline \end{array}$$

Find the differences, but do not label the answers. Ask, "Are the answers the same? Which would be the most to drink?" Then label the answers, stressing the importance of the label.

3. Assign page 31. Be sure to check answers to see that labels are correct.

4. Make up a word problem involving subtraction of metric units of capacity. Solve it on the board, then ask students to make up word problems for the class to solve.

42

9ℓ − 1ℓ = 8ℓ	7ℓ − 7ℓ = 0ℓ	6ℓ − 0ℓ = 6ℓ	10ℓ − 5ℓ = 5ℓ	9ℓ − 8ℓ = 1ℓ	7ℓ − 2ℓ = 5ℓ
6dℓ − 1dℓ = 5dℓ	9dℓ − 3dℓ = 6dℓ	7dℓ − 5dℓ = 2dℓ	6dℓ − 2dℓ = 4dℓ	10dℓ − 1dℓ = 9dℓ	8dℓ − 4dℓ = 4dℓ
7cℓ − 6cℓ = 1cℓ	4cℓ − 2cℓ = 2cℓ	9cℓ − 5cℓ = 4cℓ	5cℓ − 3cℓ = 2cℓ	8cℓ − 5cℓ = 3cℓ	5cℓ − 1cℓ = 4cℓ

31

the 4th collpany

section 14 · mass (weight): comparison

Objectives: Given two equal masses, state that the masses remain equal when changed into different shapes. (Mastery not expected of all children at this age level.)

Given three objects with different masses, determine the heaviest (or lightest) by using a balance.

Vocabulary: mass, weight, balance, level, balanced

Materials: three identical milk cartons, balance, a variety of objects to weigh, and two lumps of modeling clay or Playdoh

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Before class place objects in three identical milk cartons so that they vary in weight. Hold up two of them and ask, "Can we tell which milk carton is heavier just by looking?" Have a student come forward to determine the heavier by feel.

   Then demonstrate how to use a balance to determine the heavier of two objects. Bring out the following points for correct use of the balance. a) The pans must be balanced before you put anything on them. b) If one object is heavier or has more mass than the other, it is on the lower pan. c) If objects have the same weight or mass, the pans are balanced.

2. Using a balance to demonstrate, discuss the six examples on page 32. Note that: 1) sometimes little things are heavier than big things; 2) sometimes neither object is heavier ("we say they have the same weight or mass") and the balance balances or stays even; and 3) even if things are the same size one may be heavier than the other. Make some specific comparisons to point these out. For example: large styrofoam ball and small steel ball, small steel cube and small aluminum cube, glass marble and same-sized steel ball, two gram weights, two identical boxes with different contents.

3. Now place the three milk cartons on the table and ask, "Can anyone use the balance to show us which carton is the heaviest?"

   First place two cartons on the balance to determine the heavier of the two. Then compare the heavier to the third carton. Repeat with three other objects. Let students volunteer to find the heaviest.

4. Repeat, using the term "lightest". The lightest object goes up on the balance.

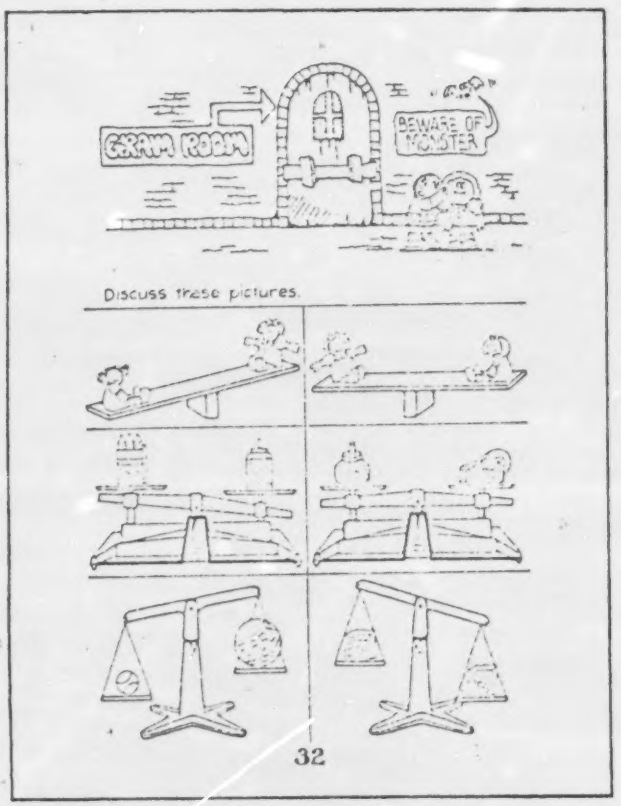
5. Prepare a weighing station with six objects and a balance. Label three objects 1, 2, and 3; label the others A, B, and C. Identical milk cartons filled with objects work very well. Working in pairs, students are to find the heaviest of objects A, B, and C, and the lightest of objects 1, 2, and 3. They record their findings on page 33.

6. As a demonstration take two lumps of clay or Playdoh and add to or take away from them until they balance "exactly". Discuss with the students what this means. Then take one lump

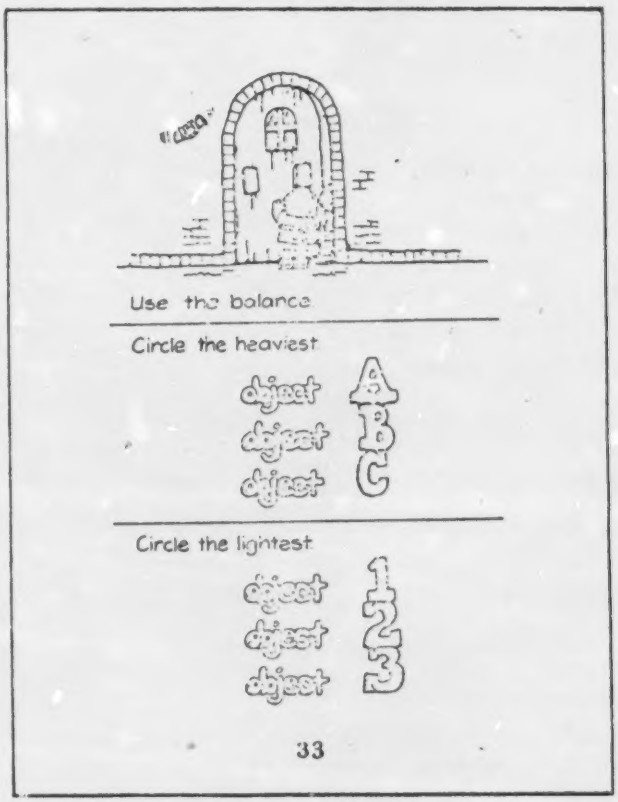
and squash it into a flat shape. Ask the students if the two lumps will still balance. Try balancing them.

Change the shape to a cigar shape and do the same. Roll them back into balls and break one lump in two. Discuss what will happen; will they balance?

Break the other lump into 4-5 pieces, and discuss the consequences. Remind the students that the quantity or mass of clay has not changed so that the overall weight of each of the two masses of clay should not change either, even though their shapes do.



32



33

the 4th company

section 5 · mass(weight):arbitrary units

Objectives: Given a balance and arbitrary weights, determine the mass (weight) of a small object.

Vocabulary: mass, weight, balance, level, balanced

Materials: balance, 15-20 pennies, box of paper clips, several small objects to weigh (label three 1, 2, and 3)

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Have a volunteer hold an object in one hand and some pennies on the other. Have him estimate how many pennies it will take to balance the object. Then let him weigh the object in pennies on the balance. Write the number of pennies on the board, being sure to write "pennies" after the number.

   Repeat with several other light objects.

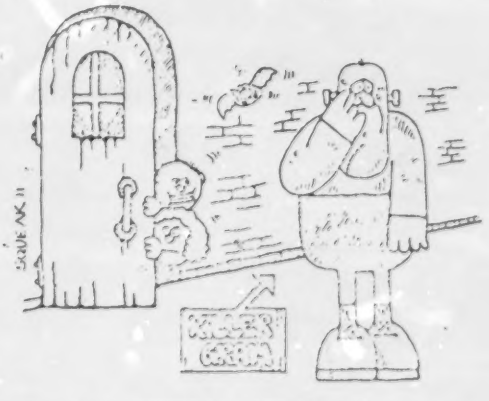
2. Now weigh a new pencil using two different arbitrary units: pennies first, then paper clips. Write the measurements on the board:

   2
   10

   Ask, "I weighed the same object, why do I get two different numbers for its weight or mass?" The students should tell you that you used two different units. Use this as an opportunity to emphasize the necessity of writing the unit with the number when we measure. Just like measures in length and capacity, measures in weight (mass) must be labeled. Label the measures on the board.

   2 pennies
   10 paper clips

3. Set up a weighing station with three small objects to weigh. Label them 1, 2, and 3. Students are to use a balance and paper clips to determine the mass of each object. Record answers on page 34.



Use a balance and paper clips

object 1 weighs _____ paper clips

object 2 weighs _____ paper clips

object 3 weighs _____ paper clips

34

the 4th collpony

section 16 · mass(weight):gram

Objectives: Given a balance and one gram weights, determine the mass (weight) of a small object to the nearest gram.

Spell "gram".

Vocabulary: gram, g, gram weight

Materials: balance; gram weights; various items to weigh, including 3 objects labeled A, B, and C to weigh in grams; 1 pound box of raisins

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Recall for the students their previous experience weighing objects using paperclips. Ask, "If I went to a candy counter and asked for 15 paperclips of peanuts (or candy corn), would the clerk know how much I wanted?" Explain that the unit for weight (mass) used by most people in the world is the gram. The gram is a certain amount and no matter who says "1 gram" or where they say "1 gram", it always means the same amount to everyone. Pass around some gram weights. Explain, "Each of these cubes weighs 1 gram. Hold it in your hand so you can feel how much everyone means when they say '1 gram'. If I went to a candy counter anywhere and asked for 15 grams of peanuts (or candy corn), the clerk would always give me the same amount. The symbol for gram is 'g'." Write "gram" and "g" on the board.

2. Use a variety of objects weighing from 1 to 25 grams. Let a student come forward and hold an object in one hand and gram weights in the other to guess its weight (mass) in grams. Then let the student weigh the object using a balance and gram weights. To keep the class interest, let them count the gram weights as the one student places them on the balance.

3. Assign pages 35, 36, 37 and 38. Pages 35 - 37 can be assigned as seatwork while the teacher helps two students at a time to complete page 38. For page 37, explain that we add grams just like we add other metric units. Students will need a balance, gram weights, and two objects labeled A and B. Have the students guess the weights, then weigh the objects on the balance and record the measures on page 38. When each student completes the page, let the student weigh out 10 grams of raisins for a treat.

4. Remind the students that the symbol for gram is "g". Have children be on the lookout for that symbol on boxes and cans in the grocery store. Bring some soup cans or cereal boxes listing contents in grams. Have children look at labels on cans and jars at

home and bring in some that give weight in grams. Make a bulletin board display of these labels.

Bulletin Board Suggestion:

5. In reviewing page 35 drill the students on the spelling of "gram". Have them close their eyes and spell the word aloud, in unison.

Trace the dotted lines. Then write gram and its symbol on your own.

gram g

gram g

35

There are 2 words and 3 symbols for gram hidden in the picture. Can you find them?

36

SECRET CODE

0g = K	6g = A
1g = I	7g = T
2g = L	8g = O
3g = E	9g = G
4g = R	10g = M
5g = S	

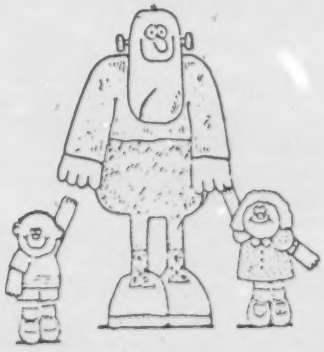
-3g	-3g	+1g	-1g	+2g	+2g
0g	1g	2g	2g	3g	4g
K	I	L	L	E	R

+5g	-1g	+4g	+5g
9g	4g	6g	10g
G	R	A	M

-4g	+3g	+1g	+3g
3g	6g	7g	5g
E	A	T	S

-6g	+0g	+1g	+2g	+2g	-2g	+5g	+4g	-1g
0g	1g	2g	8g	9g	4g	6g	10g	5g
K	I	L	O	G	R	A	M	S

37



A about _____ grams

B about _____ grams

38

the 4th collection

section 17 · mass(weight): kilogram

Objectives: Given illustrations of dials calibrated in kilograms, record the indicated weight.

Given a bathroom scale calibrated in kilograms, determine one's own weight to the nearest five kilograms.

Vocabulary: kilogram (kg), kilogram weight, kilogram scale, dial

Materials: gram weights, kilogram weight, balance, metric bathroom scale

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Let the children feel a gram weight. Recall that a meter is divided into 10 parts called decimeters, and that a liter is divided into 10 parts called deciliters. "What would a decigram be? Would it be more or less than a gram?" Point out that it is less than a gram and that 10 decigrams make 1 gram. Write the following on the board.

   meter liter gram
   decimeter deciliter decigram

   Ask if a decigram is very heavy. Explain that since it is so light, we don't use decigrams very often. You may mention that centigrams are even smaller, and hence are not used by most people. Use a metric wall chart to point out the order of the prefixes for meter, liter, and gram. Do not belabor the point. The idea is to let the children know that decigrams and centigrams do exist.

2. Introduce the kilogram. Write "kilogram" and its symbol "kg" on the board. Explain that since grams are so light, kilograms are used to weigh heavy objects. Point out that "kilo" means one thousand, so a kilogram is 1000 grams. Let each child lift the kilogram weight. Place the kg weight on the balance and have students find objects that weigh about one kilogram.

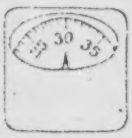
3. Explain that instead of using a balance and kilogram weights to weigh heavy objects, we use scales. Introduce the bathroom scale. Point out the dial and show how the numbers move when the scale is pressed. Ask a volunteer to come forward to be weighed. Use page 39 to explain how to read the dial. Point out that the long marks are at one kilogram intervals and that every five kilograms are numbered. Have children try to read the scale to the nearest kilogram. If they have difficulty, show them how to read it to the nearest five kilograms, i.e. to the nearest number written on the scale. Have students complete page 39.

4. Have students turn to page 40 and discuss the various scales. Ask students what kinds of scales they have seen and where. Display any scales you have available. Assign pages 40 - 43. While students work at their seats let each student weigh himself on the bathroom scale and record that weight on page 43. Watch each student to make sure he understands how to read the scale. Accept accuracy to the nearest five kilograms.

5. Have students look at bags of rice and other big food items at home and at the store to find weights written in kilograms. Remind them the symbol for kilogram is "kg". Add kilogram labels to the bulletin board display from Section 16.

Read these scales in kilograms

45 kilograms


30 kilograms

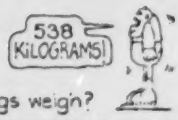
10 kilograms

15 kilograms

75 kilograms

60 kilograms

39

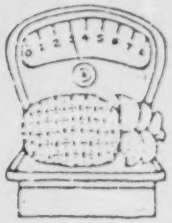


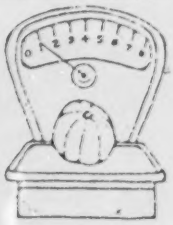
How much do these things weigh?

4 kilograms

5 kilograms

8 kilograms


3 kilograms


1 kilograms

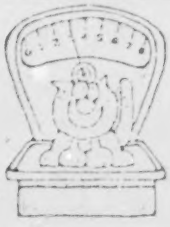
40

How much do these things weigh?

4 kilograms

0 kilograms

6 kilograms

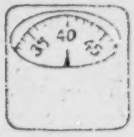

3 kilograms

2 kilograms

30 kilograms

41

Read these scales in kilograms


40 kilograms

10 kilograms

65 kilograms

25 kilograms

5 kilograms

55 kilograms

42

Trace the dotted lines. Then write kilogram and its symbol on your own.

kilogram kg

kilogram *kg*

How much do you weigh? _____ kilograms

43

the 4th collpany

section 18 · temperature

Objectives: Given illustrations of two thermometers, identify the hotter/colder.

Given an illustration of a thermometer, record the temperature to the nearest ten degrees.

Given an illustration of a thermometer, shade it to show a specified temperature.

Vocabulary: temperature, thermometer, degrees Celsius, °C

Materials: 5-6 Celsius thermometers, hot water, glass of ice cubes

SUGGESTED PROCEDURE AND ACTIVITIES:

1. Hold up a thermometer and ask students if they know what it is and what it measures. Explain that thermometers are used to measure temperature, how hot or cold something is. Set out a container of hot water and a container of ice water. Ask what will happen if the thermometer is placed in the cold water. The hot water. Place the thermometer from one to the other so that students can see the red line go up and down. Explain that the higher the red line, the hotter, and vice versa. Use the words hotter, colder, warmer, and cooler.

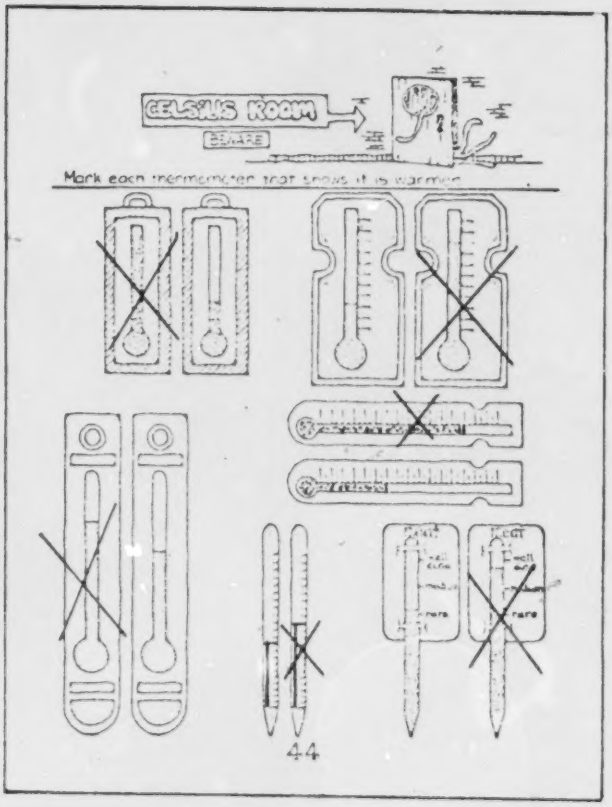
2. Assign page 44. Students are to mark the thermometer which shows the warmer temperature.

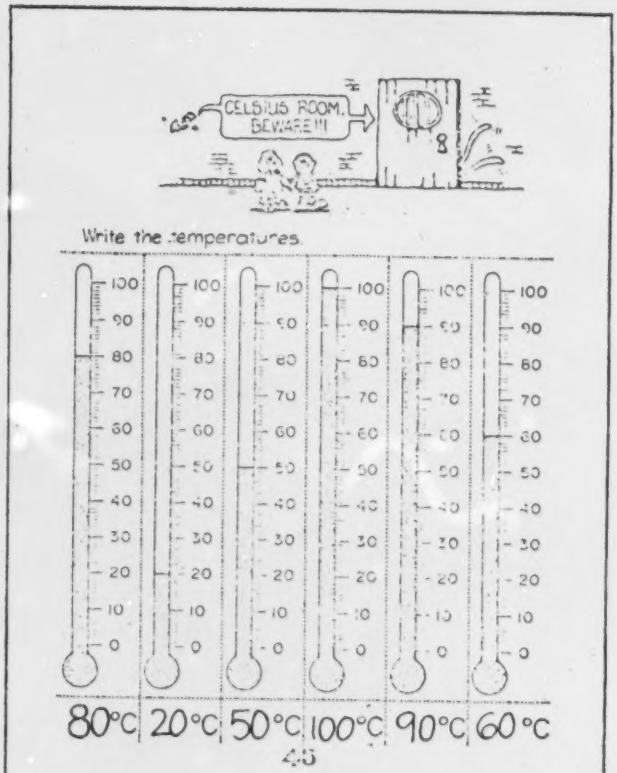
3. Explain that "°" is the symbol for degrees and that "C" is the symbol for Celsius. Thus, we measure temperature in degrees Celsius, or °C. Write several temperatures on the board and have the students read them aloud: 92 °C is read "ninety-two degrees Celsius", etc.

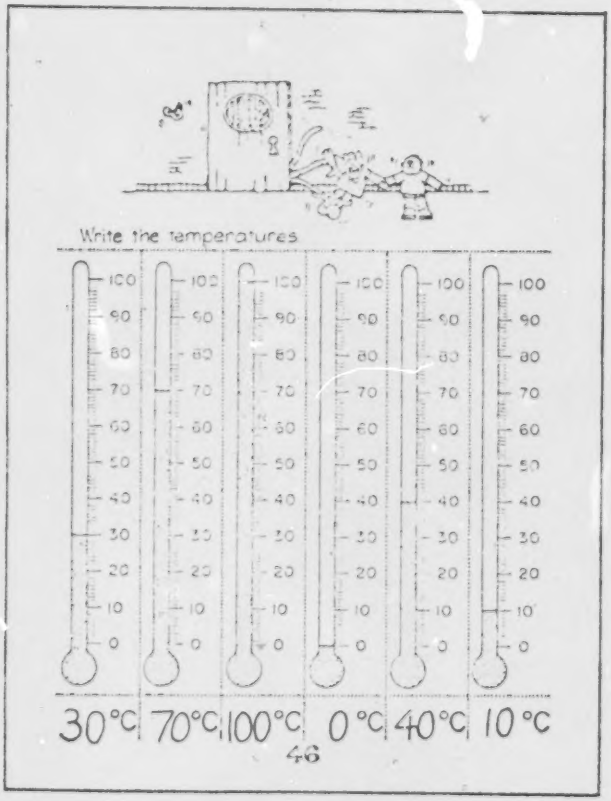
4. Write pairs of temperatures on the board and have students identify the hotter or colder:
   56 °C or 65 °C 72 °C or 89 °C

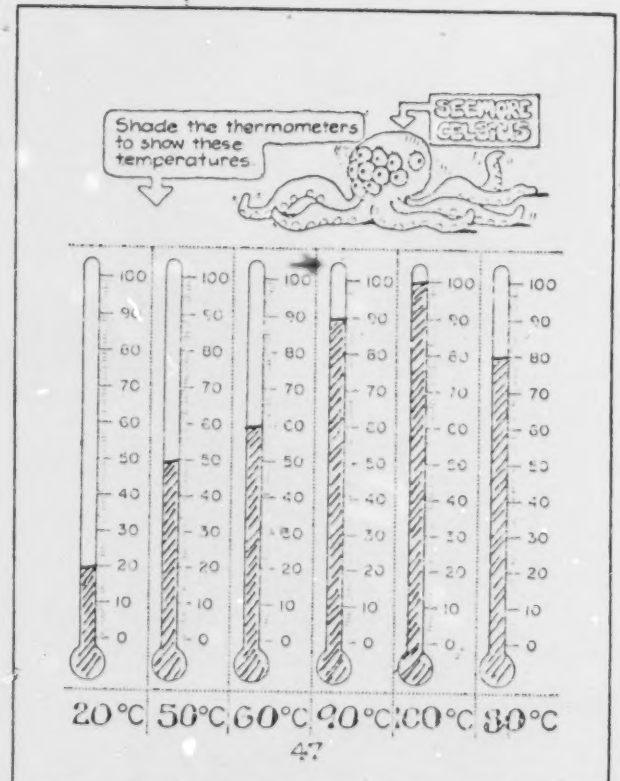
5. Explain that thermometers are used to tell when we are sick. Normal temperature is 37 °C.

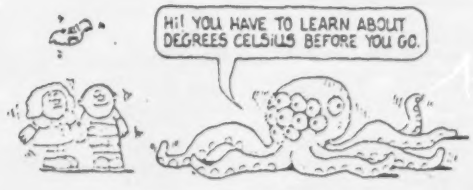
6. Assign pages 45 - 48. On pages 45 and 46 have students read the thermometers to the nearest 10 degrees and record the temperatures. On page 47, students are to shade the thermometers to show the given temperatures. While students work on pages 45 - 47, let pairs of students go to the temperature station, read the thermometers, and record the temperatures on page 48. At the station you will need two glasses of water labeled A and B, one cold and one warm, with a thermometer in each. You should supervise this activity rather closely. Answers will vary.


CELSIUS ROOM
BEWARE
Mark each thermometer that shows it is warming
44


CELSIUS ROOM.
BEWARE!!!
Write the temperatures
80°C 20°C 50°C 100°C 90°C 60°C
45

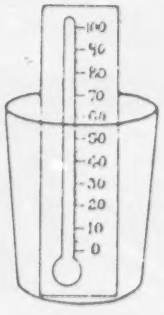

Write the temperatures
30°C 70°C 100°C 0°C 40°C 10°C
46


Shade the thermometers to show these temperatures.
BEEMORE CELSIUS
20°C 50°C 60°C 90°C 100°C 30°C
47

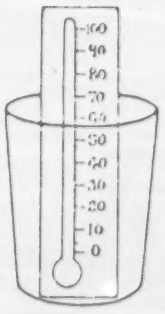


Read the two thermometers at the measuring station.

A ____°C



B ____°C



48

the 4m company

section 9. "I measure me"

Objectives: Given printed pages with measurement directions, complete an "I Measure Me" booklet.

Vocabulary: none

Materials: centimeter rulers, cm tape measure on wall, cloth tape measures, bathroom scale, paper fasteners or staples

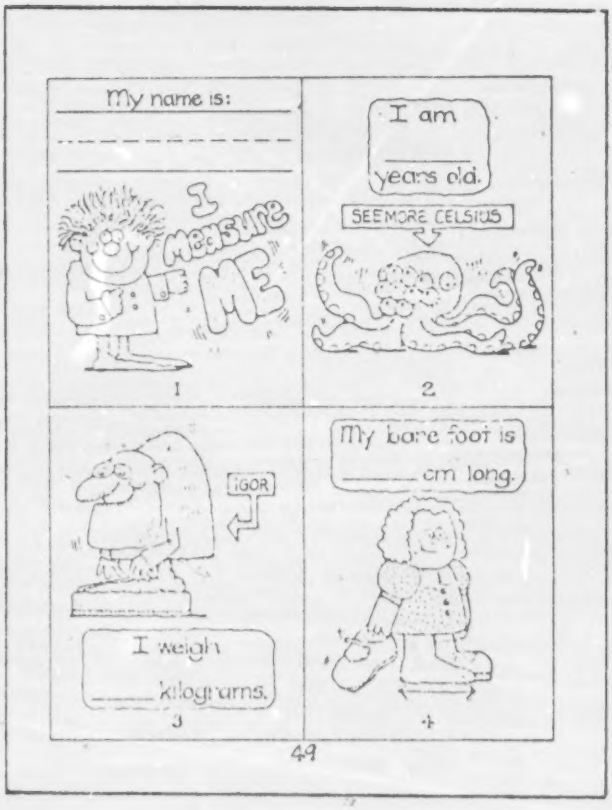
SUGGESTED PROCEDURE AND ACTIVITIES:

1. Explain to the class that they are going to complete the "I Measure Me" section of their metric book. They will need cm rulers, tape measures, and a bathroom scale. Demonstrate how to use a cloth tape measure to measure their waists, their muscle (bicep), etc. Put a strip of paper marked off in cm on one wall of the door where the students can use it to measure their heights. Demonstrate its use with a student, pointing out the need for heels against the wall, head level, etc.

2. Read through pages 49 and 51 so the students know what to fill in on each page of their I Measure Me booklets. You may wish to make blank pages for students to fill in with any measures they want to make. Write some suggestions on the board. The students may draw pictures to illustrate them. A few suggestions are:

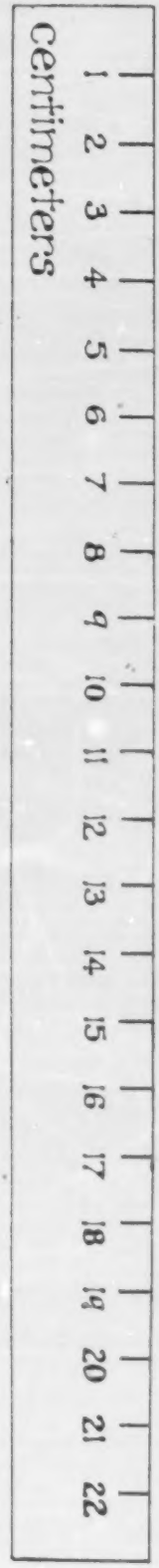
   I can reach to ____ cm.
   My head is ____ cm around.
   My wrist is ____ cm around.
   My friend and I weigh ____ kg together.
   My hair is ____ cm long.
   One meter is this high on me. (Draw a picture to show this.)

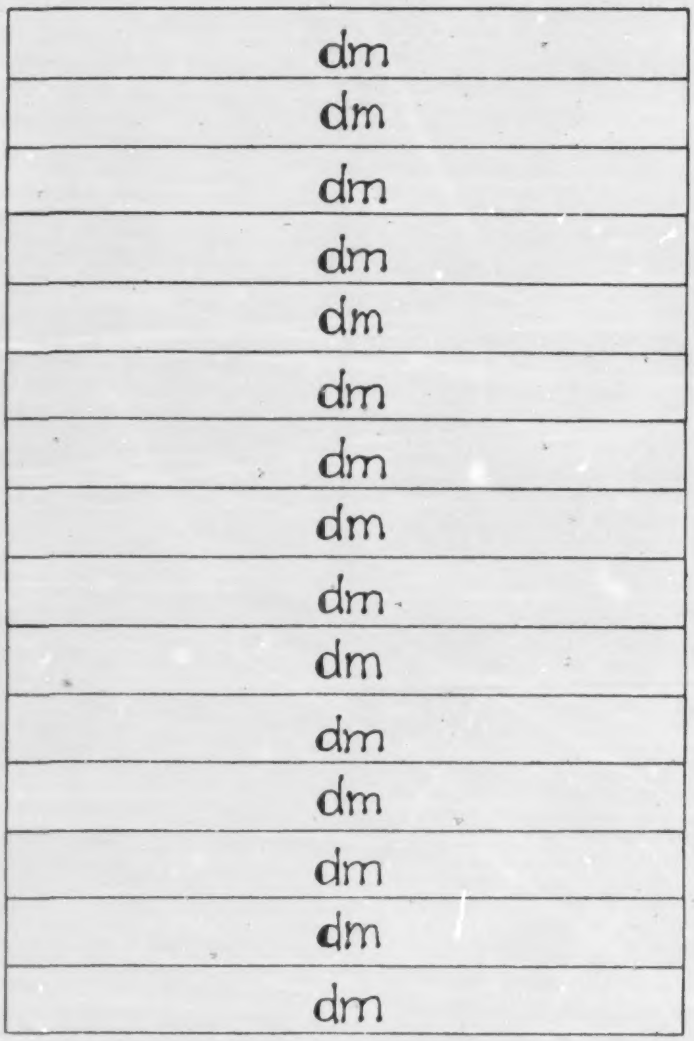
3. When students have filled in their pages, they can cut them apart, put them in order, and secure their booklets with staples or paper fasteners. (Using paper fasteners will allow students to add pages later if that is desirable.)


My name is:
I MEASURE ME
1
I am
years old.
SEEMORE CELSIUS
2
IGOR
I weigh
kilograms.
3
My bare foot is
cm long.
4
49

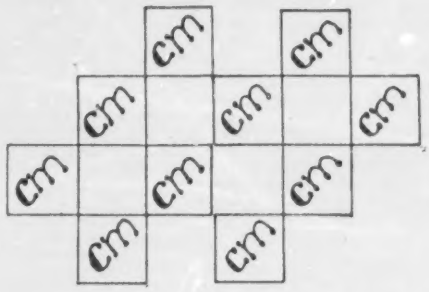
KILLER GRAM
My chest is
cm around.
5
My waist
is cm.
METER MUMMY
6
DRACULITER
My height is cm.
7
My muscle
is cm.
8
51

SECTION 5. Centimeter ruler.

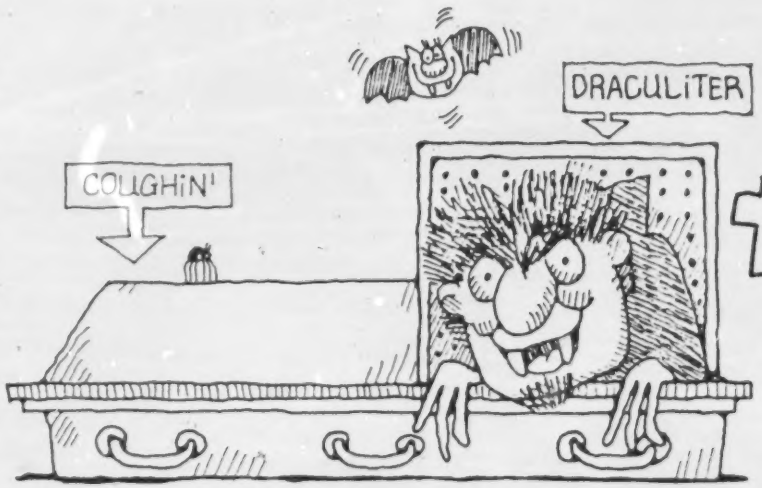




SECTION 4 & 5. Decimeter strips.

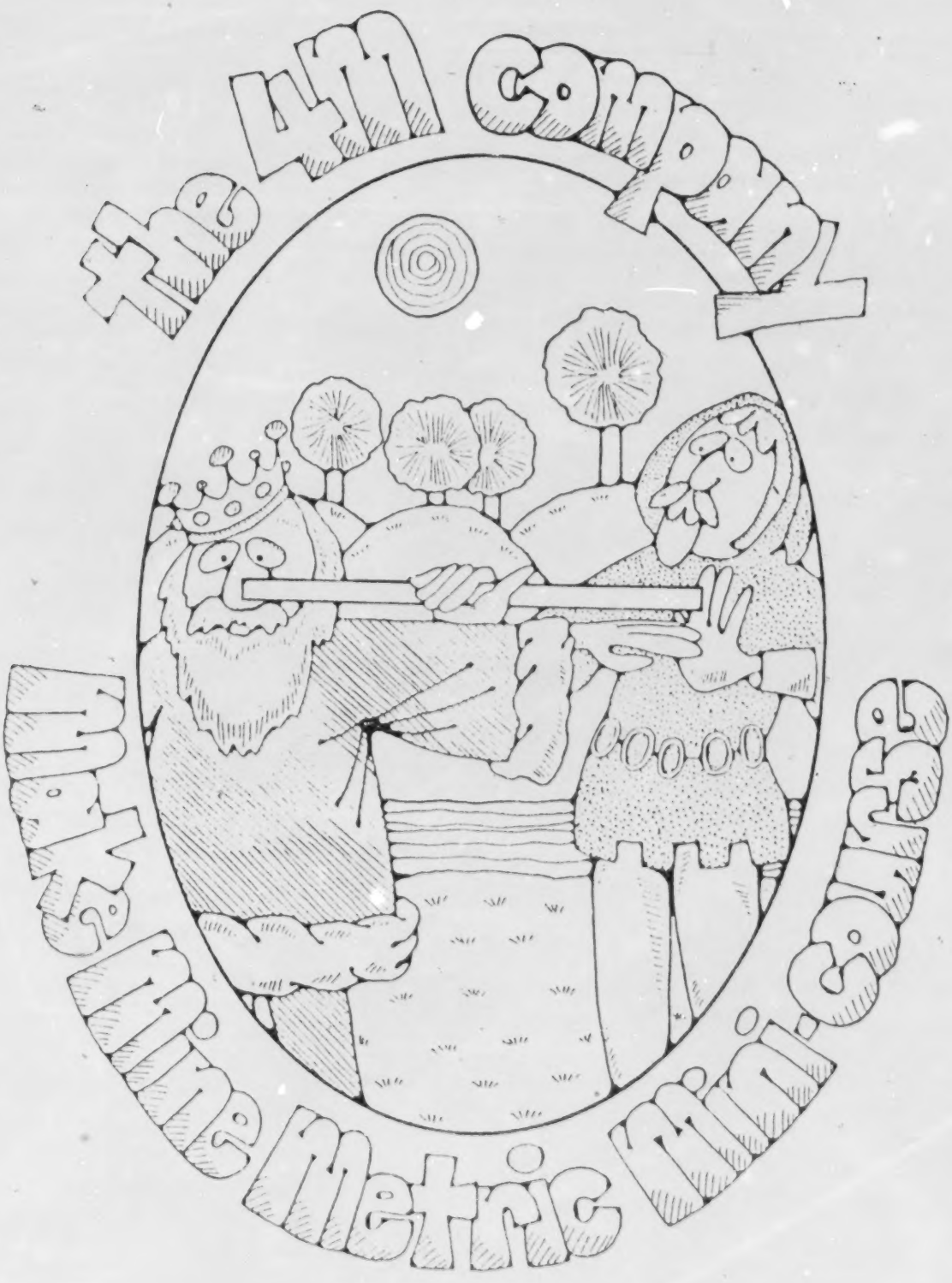


SECTION 5. Centimeter units.



Learn the Metric System

1000	kilometer (km)	kiloliter (kl)	kilogram (kg)
100	hectometer (hm)	hectoliter (hl)	hectogram (hg)
10	dekameter (dam)	dekaliter (dal)	dekagram (dag)
1	meter (m)	liter (l)	gram (g)
0.1	decimeter (dm)	deciliter (dl)	decigram (dg)
0.01	centimeter (cm)	centiliter (cl)	centigram (cg)
0.001	millimeter (mm)	milliliter (ml)	milligram (mg)



© 1976 University of Hawaii
College of Education
Curriculum Research and Development Group

INTRODUCTION

This mini-course is designed to serve two purposes: 1) a quick review of metrics for teachers who have attended a metric workshop; and 2) a basic introduction to the metric system for teachers who have not attended a metric workshop. If studied seriously, we feel the contents of this mini-course can prepare a teacher to teach the metric system. However, don't expect to be an expert right away. Even teachers who have attended a workshop frequently forget much of what they learned. As most teachers know, we usually don't know a subject well until we have taught it a time or two. The same will be true of metrics.

TABLE OF CONTENTS

Lesson 1: The Meter, the Liter, and the Gram . . . . . page 1

Lesson 2: Other Units -- Presto! . . . . . page 2

Lesson 3: Practice with Prefixes . . . . . page 3

Lesson 4: A Brief History of the Metric System . . . . . page 4

Lesson 5: Temperature . . . . . page 7

Lesson 6: Mass (Weight?) . . . . . page 8

Lesson 7: SI . . . . . page 9

Lesson 8: SI Style Conventions . . . . . page 11

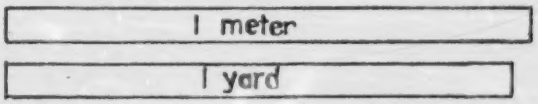
Next-to-last Lesson: Decimals . . . . . page 13

Last Lesson: Metric for Everyday Living . . . . . page 14

LESSON 1: THE METER, THE LITER, AND THE GRAM

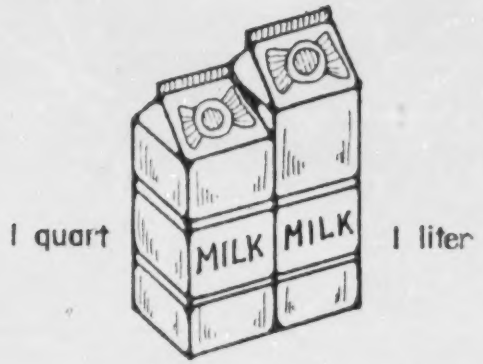
The three most common metric units are the meter (for measuring length or distance), the liter (for measuring liquid or granular capacity), and the gram (for measuring weight). Select a meter, a liter, and a gram from your metric supplies.

The meter is the main unit of length in the metric system. Stand up and hold the meter stick on the floor against your leg. How high up your leg does it come? To your hip? To your waist? Remember the spot and you'll always have some idea of a meter. A meter is just a little longer than a yard -- 39.36 inches.

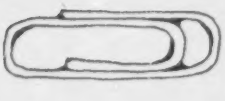


The liter is the main unit of capacity in the metric system. It was originally defined to be the capacity of a cube each of whose sides was 1/10th of a meter long.

Take a good look at the liter. Does it appear to be about the size of any English unit? Actually, the liter is slightly larger than a quart (6% larger, to be exact).



Now pick up the gram, the main unit of weight in the metric system. Pretty light, isn't it? If you look at the protein, fat, and carbohydrate content of the sides of cereal boxes you'll notice that the weights are given in grams. A paper clip weighs about one gram. A nickel weighs 5 grams.


weighs 1 gram

weighs 5 grams

These three units - meter, liter, and gram - are the heart of the metric system necessary for everyday measuring. Try to remember the size of each unit: the meter is a little longer than one yard; a liter is a little larger than a quart; and a gram is the weight of a paper clip.

LESSON 2: OTHER UNITS - PRESTO!

In the English system of measurement there are 14 units of length, and there is no systematic relationship between them:

12 inches = 1 foot

3 feet = 1 yard

5½ yards = 1 rod

40 rods = 1 furlong

8 furlongs = 1 mile

etc.

One would have to be a near-genius to remember all the relationships in the English system!

By comparison, the metric system is simple (although it may not seem so at first). In the metric system there is one base unit for each physical property to be measured. To form units larger or smaller than the base units, a system of prefixes, each of which is a power of ten, is used. For units smaller than the base units, the Latin words for tenth, hundredth, and thousandth are used (deci, centi, and milli). To form units larger than the base units, the Greek words for ten, hundred, and thousand are used (deka, hecto, and kilo). The new units are formed by placing the prefixes in front of the base units.

	LENGTH	CAPACITY	MASS (WEIGHT)
1000	kilometer (km)	kiloliter (kℓ)	kilogram (kg)
100	hectometer (hm)	hectoliter (hℓ)	hectogram (hg)
10	dekameter (dam)	dekaliter (daℓ)	dekagram (dag)
1	meter (m)	liter (ℓ)	gram (g)
0.1	decimeter (dm)	deciliter (dℓ)	decigram (dg)
0.01	centimeter (cm)	centiliter (cℓ)	centigram (cg)
0.001	millimeter (mm)	milliliter (mℓ)	milligram (mg)

Whenever kilo is heard, we know immediately that we have 1000 of the base unit, whatever it is. Thus, kilometer is 1000 meters, kiloliter is 1000 liters, kilowatt is 1000 watts, etc. (The watt is a unit of power.) Or, millimeter is 0.001 meter, milliliter is 0.001 liter, etc.

The writing of metric units is simplified by the use of symbols: m stands for milli, c for centi, d for deci, da for deka (the a is needed to distinguish deci from deka, both of which start with d), h for hecto, and k for kilo. Also, m for meter, ℓ for liter, and g for gram. Thus kg is kilogram, mℓ is milliliter, etc. In the next lesson you will practice using these metric prefixes.

LESSON 3: PRACTICE WITH PREFIXES

In this lesson you will practice using metric prefixes. Use the table in Lesson 2 to help you complete the following equations. Answers appear at the end of the Teacher's Guide.

100 grams =	hectogram	100 liters =	
10 liters =		1000 liters =	
1000 meters =		1000 grams =	
0.001 gram =		10 meters =	
100 liters =		0.1 meter =	
0.01 gram =		0.1 liter =	
0.001 meter =		0.01 liter =	
0.01 meter =		0.1 gram =	
0.001 liter =		10 grams =	

Keep going! Try these!

10 cards = dekacards (get it?)

0.1 Arnaz = _____

0.01 mentalist = _____

1000 manjaros = _____

0.001 tary = _____

0.1 mate = _____

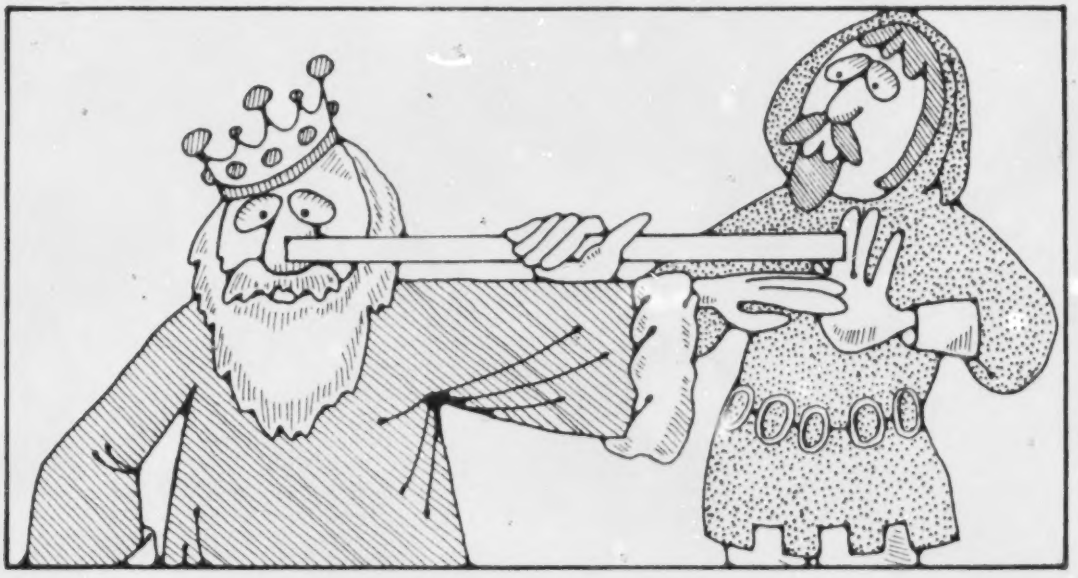
1000 whats? = _____

0.001 scent = _____

0.01 pede = _____

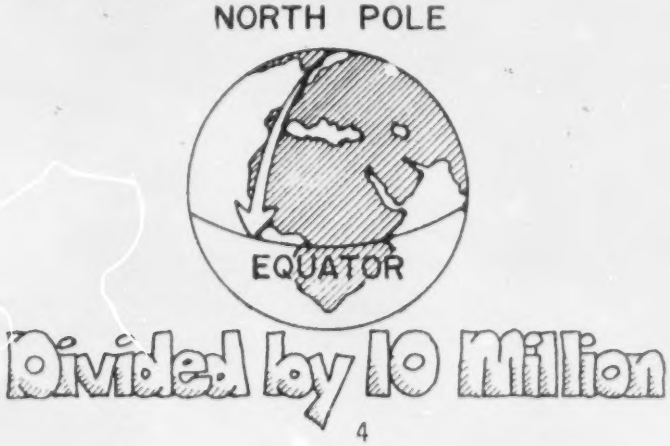
LESSON 4: A BRIEF HISTORY OF THE METRIC SYSTEM

Prior to 1790, the measurement systems of Europe were based on arbitrary objects: an inch was once defined to be the length of 3 kernels of barley corn placed end-to-end; a rod was the combined left feet of the first 16 men coming out of a specific church on Sunday morning; an acre was the amount of land a team of oxen could plow in one day; the yard was the distance from the tip of King Henry I's nose to the tip of his extended middle finger; etc.

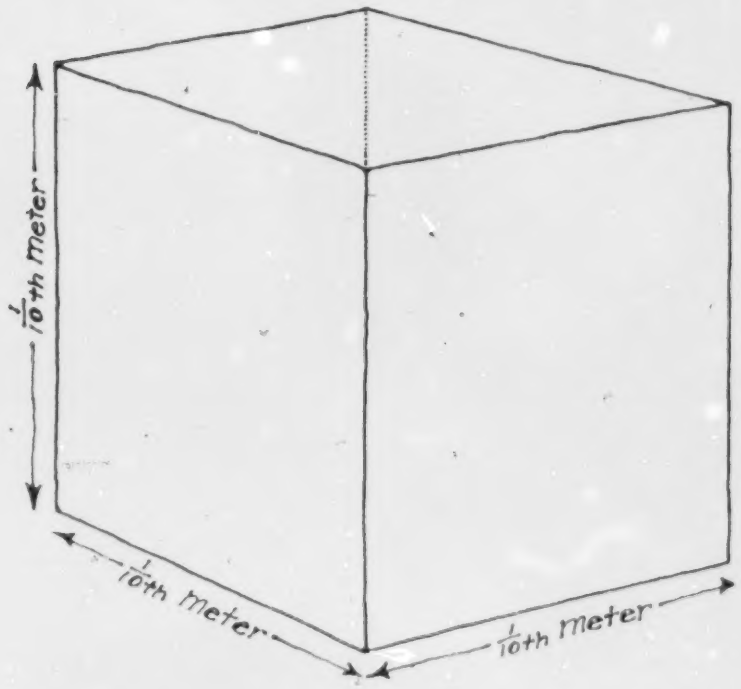


A similar hodge-podge of units was used in France at the time of the French Revolution. In 1789, the French Academy of Sciences was requested by the National Assembly to devise a new measurement system. The French Revolution was underway, and because of the antiaristocratic attitude of the French people, a change to a system not based on dimensions of royal monarchs was highly acceptable to them.

In developing the metric system the French scientists had three major objectives. The first objective was to find a unit of length that was measurable and reproducible everywhere, and natural in the physical world. To meet this objective, the meter was defined to be one ten-millionth of the distance from the equator to the north pole.

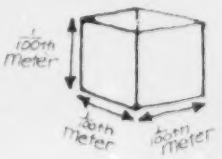


The second objective was to relate the unit of length to other units of measurement. For the main unit of capacity they selected a cube, with each of its sides equal to 1/10th of a meter (cubic decimeter), and called the amount of space contained within this box-shaped figure a "liter."



Liter

For the main unit of mass, the French scientists took a cube with each of its sides equal to 1/100th of a meter (a cubic centimeter), filled this box with pure water at 4° Centigrade, and designated the mass of this water as a "gram." Thus, the meter was used to define both the liter and gram.



Gram

The third objective was to simplify the conversion from one unit to another. We have already seen how a system of prefixes, which are powers of ten, was used to accomplish this objective. Since each metric unit is ten times larger than the next smaller unit, converting from one unit to another can be accomplished by merely moving a decimal point. Thus

35 meters =
- 0.035 kilometers
- 0.35 hectometers
- 3.5 dekameters
- 350 decimeters
- 3500 centimeters
- 35 000 millimeters

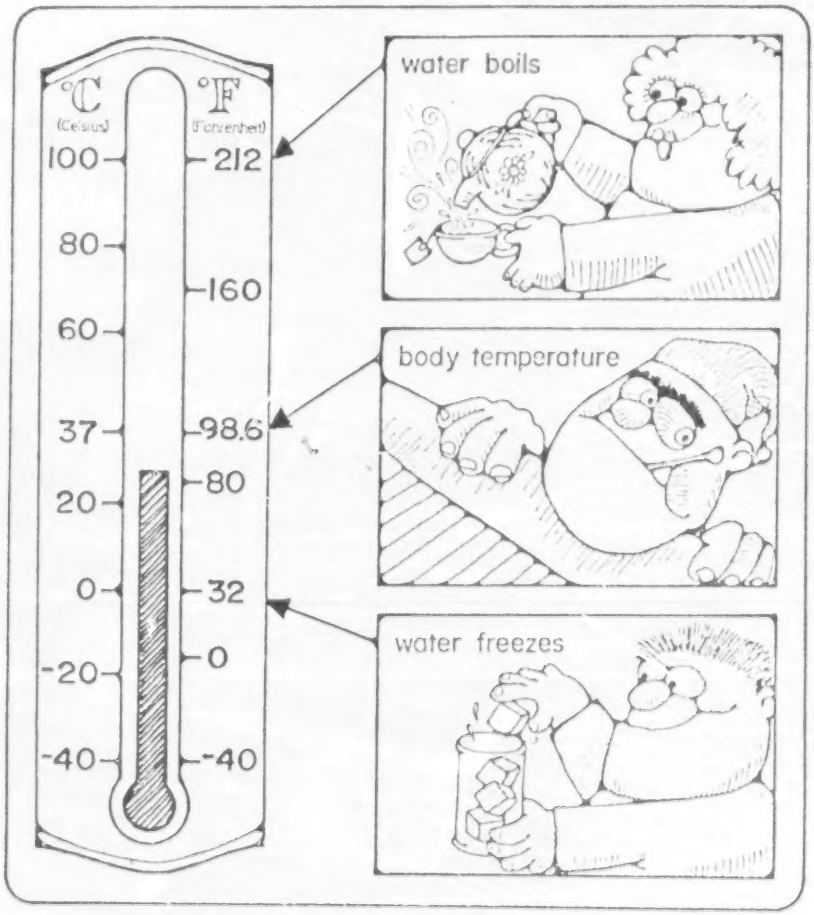
Scientists adopted the metric system immediately, for it made their work much simpler. Nations, on the other hand, have been slow to adopt it. It wasn't until 1840 that the French government made its use mandatory. By 1900, thirty-five nations had officially adopted it, and by the middle of this century, the main holdouts were the English-speaking nations. In 1965, England joined the European Common Market. Since Europe used the metric system, England decided to go metric. The other English-speaking nations soon followed. Ten years later, President Ford signed the Metric Conversion Act of 1975. Finally, after 180 years, the conversion to metric is nearing completion.

LESSON 5: TEMPERATURE

There is one more metric unit which is encountered in daily living, the unit for temperature, degree Celsius (pronounced sell-see-us). Most adults are surprised to learn that "degree Centigrade," which they vaguely remember from their school days, has been changed to "degree Celsius."

The change came about in 1948, at the General Conference on Weights and Measures which convenes periodically to review and ratify measurement standards. A debate arose concerning the name of a unit for metric temperature. Some conferees favored the English "degree Centigrade," and others favored the French "degré centisimal". By coincidence, the centigrade scale had been invented by Anders Celsius. Since his last name started with "C," his name was selected as a compromise.

The Celsius scale is simpler than the Fahrenheit scale. The drawing below illustrates its simplicity. Water boils at 100°C and freezes at 0°C. If you can remember the four temperatures shown on the thermometer, you'll have a good beginning on making sense of the Celsius scale.



LESSON 6: MASS (WEIGHT?)

The purpose of this lesson is to explain the difference between mass and weight. The kilogram is the unit of mass, and the Newton (after Sir Isaac Newton) is the unit of weight.

If you were an astronaut in outer space, the objects in your space craft would have very little weight. If you held a bowling ball in your hand and released it, it wouldn't fall. It would remain suspended in space. If the bowling ball were placed on a scale, it would read zero. It would be weightless. Why? Because the bowling ball is so far from the earth that it has escaped the pull of the earth's gravity.

Weight, then, is a measure of gravitational pull on an object. The weight of an object can vary, depending on where it is in the universe.

The mass of an object never varies. It is the same on earth as anywhere else in the universe. Mass is a measure of how much matter an object contains. The bowling ball is weightless in space, but it still has the same mass. Because of its mass, if you kicked it with your bare foot it would still hurt, whether you were on earth or in a spaceship.

We determine the weight of an object by spring scales which measure the downward pull on an object placed on it. This downward force is measured in Newtons. The mass of an object, on the other hand, is determined by using a balance: the object is placed on one side and balanced with standardized mass pieces. This is what a pharmacist does when he mixes a compound.

However, the mass of an object is directly proportional to its weight on earth. That is, a one-kilogram mass has a weight of about 9.8 Newtons at sea level; a two-kilogram mass has a weight of about 19.6 Newtons; etc. Thus, either mass or weight gives us a good measure of how much matter an object contains. Therefore, in everyday usage spring scales are used for determining mass in kilograms because it is much more convenient than using a balance. The 4M COMPANY uses the words interchangeably - mass (weight). For everyday usage, the distinction is unimportant.

LESSON 7: SI

The French scientists made several errors in their original calculations. For example, they miscalculated the distance from the equator to the north pole by about 2000 meters, and instead of being equal to one cubic decimeter, the liter was actually equal to 1.000028 cubic decimeters.

To correct these errors, various scientific organizations of the world met in 1960 to devise a modern metric system which is called the International System of Units (or SI for short, after the French Le Systéme Internationale d'Unités). SI was created to meet the exacting demands for precise scientific measurement. Most of the units and prefixes will not be used by the average citizen. But for the sake of completeness, we include a list of the base units and all the prefixes.

BASE UNITS

Quantity	Name	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Two units not on the list above are commonly used with the metric system. Instead of referring to liquid capacity in terms of cubic decimeters, the liter is used. And instead of using the Kelvin for temperature, degree Celsius is used (the Kelvin scale was derived from the Celsius scale).

PREFIXES

Prefix	Symbol	Pronunciation Symbol	Multiples & Fractions
exa	E	ex´ah	1 000 000 000 000 000 000
peta	P	pet´ah	1 000 000 000 000 000
tera	T	tear´ah	1 000 000 000 000
giga	G	jī´g,ah	1 000 000 000
mega	M	meg´ah	1 000 000
kilo	k	kill´oh	1 000
hecto	h	heck´toh	100
deka	da	deck´ah	10
deci	d	dess´ih	0.1
centi	c	cent´ih	0.01
milli	m	mil´ih	0.001
micro	μ	mike´roh	0.000 001
nano	n	nan´oh	0.000 000 001
pico	p	pee´koh	0.000 000 000 001
femto	f	fem´toh	0.000 000 000 000 001
atto	a	att´oh	0.000 000 000 000 000 001

Complete these equations if you can:

1 000 000 lomania = _____

1 000 000 000 ntic = _____

0.000 001 nesia = _____

1 000 000 000 000 tory = _____

0.000 000 000 000 000 001 rney = _____

1 000 000 000 000 000 000 rcist = _____

LESSON 8: SI STYLE CONVENTIONS

Think of it! There is no universal language, there is no universal monetary system. But at last we stand on the threshold of having a universal measurement system, a system understood by people all over the world. To make communication easier, certain style conventions are recommended. This section cites the major conventions.

1. Use a space to separate large numbers into groups of three. Do not use a comma. In many countries a comma is recognized as a decimal point.

Example:	Correct	Incorrect
	600 300.6	600,300.6

2. Use a zero in front of the decimal point when the numerical value is a partial unit.

Example:	Correct	Incorrect
	0.6 mm	.5 mm

3. Use a decimal to express partial units. Avoid using fractions to express partial units.

Example:	Correct	Incorrect
	0.25 kg	1/4 kg

4. Use uppercase or lowercase letters as they are given in the table. All abbreviations or symbols are to be used in the singular form. Do not use periods after symbols unless they conclude a sentence.

Example:	Correct	Incorrect
	mm (millimeters)	mms or mm's
	cg	c.g.
	ℓ	ℓ.

5. Prefixes must be combined with units. In common usage "kilo" means kilogram. Such usage is not preferred.

6. Avoid mixing units.

Example:	Correct	Incorrect
	12.75 m	12 m 75 cm

7. Avoid using multiple prefixes.

Example:	Correct	Incorrect
	ps (picosecond)	μμs (micromicrosecond)

8. Avoid capitalization of unit names (except Celsius) unless they start a sentence. Listings should be lowercase.

Example: Correct - The base unit for mass is the kilogram.

Incorrect - The base unit for mass is the Kilogram.

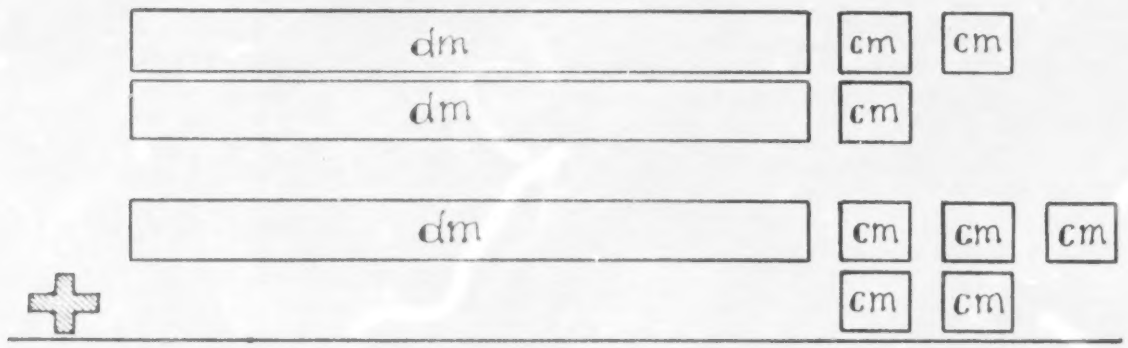
NEXT-TO-LAST-LESSON: DECIMALS

Our number system, our monetary system, and the metric system all share a common characteristic: they are decimal in nature. Because of this, the switch to metric makes the study of decimals even more important than ever. The 4M COMPANY begins the study of decimals in the third grade. The purpose of this lesson is to illustrate how the decimal nature of the metric system is used to teach decimals.

Since a decimeter is one-tenth of a meter, decimeters are used to introduce tenths. Students make a meter strip marked in tenths of meters and use it to measure various lengths.

Similarly, since a centimeter is one-hundredth of a meter, centimeters are used to introduce hundredths. And a millimeter, being one-thousandth of a meter, is used to introduce thousandths.

Addition and subtraction of decimals are explained in terms of metric units. Thus, the problem $\begin{array}{r} 0.23\ \text{m} \\ +0.15\ \text{m} \\ \hline \end{array}$ is represented as follows:



If placed end-to-end, these units would come to the 0.38 m mark on a meter marked in hundredths. Since 10 centimeters can be exchanged for 1 decimeter, borrowing and carrying are easily explained in terms of metric units. The students soon see that adding and subtracting decimals is very similar to adding and subtracting whole numbers.

LAST LESSON: METRIC FOR EVERYDAY LIVING

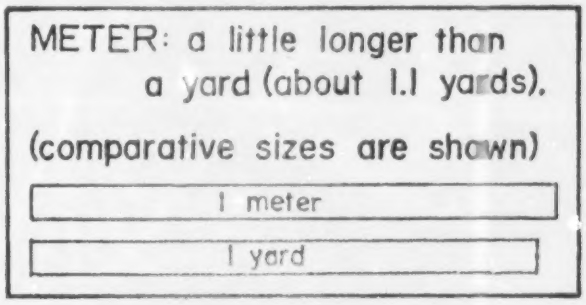
In this section we list those metric units which are most commonly used in everyday living.

Length: 1) A meter is a little longer than a yard.

2) A kilometer (1000 meters) is about 6/10th of a mile.

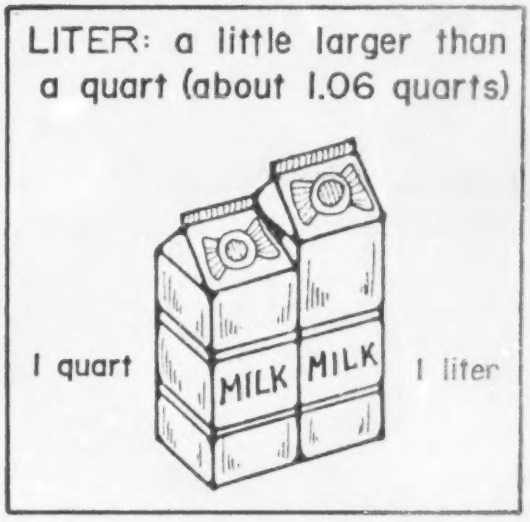
3) A centimeter (0.01 meter) is about the width of a paper clip.

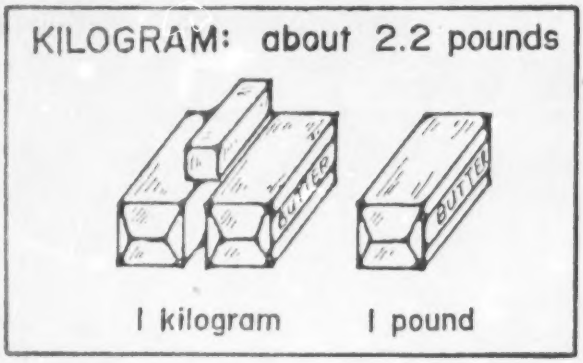
4) A millimeter (0.001 meter) is about the thickness of a dime.



Capacity: 1) A liter is a little larger than a quart (about 1.06 quarts).

2) A milliliter is 1/5th of a teaspoon.





Mass: 1) A gram is the mass of two small thumb tacks.

2) A kilogram is about 2.2 pounds.

3) A metric ton is 2200 pounds.

4) A milligram is the weight of a bee's wing.

ANSWERS TO PROBLEMS

LESSON 3:

hectogram
dekaliter
kilometer
milligram
hectoliter
centigram
millimeter
centimeter
milliliter
hectoliter
kiloliter
kilogram
dekameter
decimeter

deciliter
centiliter
decigram
dekagram
dekacards
deciArnaz
centimentalist
kilomanjaros
millitary
decimate
kilowhats?
milliscent
centipede

LESSON 7:

megalomania
jigantic
micronesia
teratory
attorney
exarcist